AIRSTRIP PAVING MATERIALS

HEARINGS

BEFORE THE

SUBCOMMITTEE ON DEFENSE ACTIVITIES

(Under authority of H. Res. 125)

OF THE

COMMITTEE ON ARMED SERVICES
HOUSE OF REPRESENTATIVES

EIGHTY-THIRD CONGRESS

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AIRSTRIP PAVING MATERIALS

WEDNESDAY, FEBRUARY 3, 1954

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON DEFENSE ACTIVITIES OF THE
COMMITTEE ON ARMED SERVICES,
Washington, D. C.

The subcommittee met, in room 304, Old House Office Building, at 10 a. m., Hon. William E. Hess (chairman) presiding.

Mr. HESS. The committee will please come to order.

We have called this meeting and we have extended invitations to individuals and associations engaged in furnishing asphalt and concrete for the paving of airstrips for the Air Force because the fast developing use of jet planes has presented two problems which must be met; to wit: The spillage of jet fuel and the claimed damage to airstrips and fire hazards resulting therefrom; and the second is the claimed damaging effect of blasts from jet aircraft, which, it is alleged, damage existing types of runways.

Of course we are not willing to concede that changing the type of runway is the complete and only answer to either of these problems. Technical progress in the construction and operation of the planes themselves may in some way reduce these hazards.

Our immediate concern, however, is with the proposed extension of runways and the improvement of others. The accent, of course, in all of this is on the cost.

The Air Force seems to be centering its interest on heavy installation of concretes. Others are just as insistent that that is not the only solution.

We are seeking information on this whole broad subject from everyone who can contribute to a better understanding of the problems, so that when authorization bills come before us we will be able to legislate intelligently. As far as I know this will be the first time there will have been developed in one place what I hope to be a reservoir of source information.

That is the reason you have all been invited here this morning to participate in the discussions. I want to thank all of you who have come here personally and on behalf of the subcommittee for your patriotic contribution in sharing with us your technical information and helping us to better understand the problems posed.

American ingenuity has never been baffled by any problem. We must be versatile, flexible, and adaptable in our approach to all problems; and we must have the broadest base for understanding what we are dealing with so that out of it all may come a rational and satisfactory solution.

Mr. Courtney.

Mr. COURTNEY. Mr. Chairman, rather than to take the time of the committee to read them, I should like to introduce in the record the three letters from the Department of the Air Force which have precipitated this hearing:

First, our inquiry of September 2, 1952, with respect to costs;

Letter from the Navy Department of June 15, 1953;

Letter from the Department of the Air Force in response to a second inquiry dated May 1, 1953; and

A letter of July 6, 1953, from the Department of the Air Force bringing the matter down to date.

Finally, on January 8, 1954, the Air Force issued over the signature of General Washburne a memorandum directed to the Chief of Engineers of the Army and to the Chief of the Bureau of Yards and Docks, establishing criteria for runway construction and for procedure on invitations for bids, and other matters relating to further construction of Air Force pavements and runways.

I think it should be part of the record.

Mr. HESS. Very well. Those matters will be made a part of the record.

(The documents referred to are as follows:)

DEPARTMENT OF THE AIR FORCE,
OFFICE OF THE SECRETARY,
Washington, September 2, 1952.

Hon. CARL VINSON,
Chairman, Committee on Armed Services,
House of Representatives.

Dear Mr. CHAIRMAN: In line with its policy of continuously obtaining the maximum value for the least expenditure of funds especially in the construction field, the Air Force in 1950 adopted the following policy with respect to airfield pavements:

"The selection of portland cement concrete or asphaltic concrete pavements to be constructed on Air Force installations will depend on which one is cheaper on the basis of first cost."

This policy was based on the assumption that there is little demonstrable difference in the cost of maintenance of the two types and also on assurances that high quality, densely graded asphaltic concrete would not be substantially damaged by the action of jet aircraft. During the last 18 months under this policy the Air Force has constructed approximately 60 percent of its pavement in the flexible type (asphaltic concrete) and 40 percent of the rigid type (portland cement concrete). The dollar cost of the two types of pavement has been approximately equal.

Experience is showing that the performance of asphaltic concrete pavements has not been as uniformly good as anticipated. An increasing number of damage reports and complaints from field commanders has been received on its unfavorable behavior under use by jet aircraft. This damage is certain to increase as the conversion of the Air Force to all-jet operation progresses.

The Air Force in its expansion program is confronted this year and next with the necessity of constructing approximately 20 million square yards of airfield pavement. In the face of increasing reports of damage to asphaltic pavement, the Air Force cannot continue the 1950 policy of always selecting the cheaper of the two pavement surfaces for all functional uses. Neither can it afford to postpone this construction to await the results of field experiments and laboratory tests of improved asphalt wearing surfaces.

After careful consideration of its position, the Air Force has approved the following criteria for airfield pavements for the fiscal year 1953 pavement program:

(*a*) Designation of selected pavement areas at permanent bases in the Zone of Interior where portland cement concrete will be specified for construction based on its functional use. These areas are aprons, runway ends, and warm-up pads.

(*b*) Continuation of present policy on all semi-permanent bases and all permanent pavement not included in above.

In addition, the Air Force has designated six jet-field aprons in the Zone of Interior for experimental construction of tar-rubber wearing surfaces. These test aprons will give the Air Force a firm answer on the feasibility of continuing to enjoy the generally lower cost of flexible pavement and at the same time secure a protective wearing surface.

The adoption of this changed criteria represents no change in Air Force policy of utilizing the least expensive construction that will fulfill its operational requirements. The Chief of Engineers has been requested to utilize the above criteria for the immediate program.

In view of the intense interest previously expressed by your committee in these matters and also a similar interest displayed by the construction industry, this latest development is brought to your attention at this time.

Sincerely yours,

ROBERT E. L. EATON,
Brigadier General, USAF,
Director, Legislation and Liaison.

DEPARTMENT OF THE NAVY,
OFFICE OF THE JUDGE ADVOCATE GENERAL,
Washington, D. C., June 15, 1953.

MR. JOHN J. COURTNEY,
Special Counsel, Subcommittee on Defense Activities,
Committee on Armed Services, House of Representatives,
Washington, D. C.

MY DEAR MR. COURTNEY: The information that you requested in your memorandum for Capt. Edward C. Stephan dated May 29, 1953, concerning construction costs on airfields is forwarded herewith.

Any further information that you require will be gladly furnished on request by you.

Sincerely yours,

G. C. GILL,
Captain, USN,
Special Congressional Liaison Officer.

INFORMATION ON AIRFIELD PAVEMENTS

The pavements of an airport must be designed to carry wheel loads without exceeding the bearing capacity of the supporting ground below the pavement, and to provide a tough, durable surface. This supporting ground is called the subgrade.

The two controlling factors as to the type, thickness, and design characteristics of the majority of pavements are the wheel loads and tire pressure, and the characteristics of the subgrade.

The wheel loads and tire pressures are established by the Bureau of Aeronautics to handle the type aircraft to be operated presently and in the foreseeable future. With the loading established, it is necessary to investigate the subgrade for each individual runway, taxiway, and parking area to determine the capabilities of the subgrade and to investigate the availability of aggregates for either type of pavement.

The cost of the asphalt flexible pavement surfacing plus the cost of the underlying materials above the subgrade is compared with the cost of the portland cement concrete plus the underlying materials above the subgrade, and the most economical type is selected.

In general, the Navy has found that the difference in initial costs of construction of the two types of pavements is extremely variable. In localities where there are no suitable materials for the suporting courses available and all such materials must be shipped in from long distances, the cost difference is not appreciable. In localities where there is an abundance of suitable supporting materials (base course and subbase materials) the cost of flexible pavement is approximately two-thirds the cost of concrete. There are some localities that do not have locally available aggregates for the supporting courses of flexible pavement but do have available concrete aggregates whereby the cost of concrete pavement is cheaper than the flexible-type pavement.

There are portions of airport pavements where you introduce another factor in the selection of type pavement which controls the selection regardless of wheel load and subgrade—it is the effects of jet blast and fuel spillage. Since asphalt is soluble in hydrocarbon fuels (gasoline and kerosene) and cannot withstand temperatures in excess of 300° F., the Navy has adopted the policy of paving all parking areas, warm-up pads or aprons, runway ends (end 500 feet) and holding areas at junctions of taxiways and runways with concrete. This policy was also established to preclude damage to costly aircraft and hazard to lives of pilots and crews since the jet blasts are known to soften bituminous surfacings and dislodge hard aggregate particles in all areas where the jet planes power check.

The initial cost of pavements for runways is approximately $10 per square yard. This is an overall figure for runways, taxiways, and parking areas. A breakdown of the unit costs that make up a pavement are brought out in the case studies attached of pavement construction at NAS Whidbey Island (concrete); NAS Miramar (concrete); NAS Cecil Field (concrete and asphaltic concrete); NAS Chincoteague (concrete and asphaltic concrete); NAS Brunswick (concrete and asphaltic concrete); and NAS Port Lyautey, French Morocco (concrete).

The maintenance and operation costs of runways were compiled each year by the Bureau of Aeronautics, the Bureau that budgets for and allocates the funds for the maintenance of the Naval air stations, and it was found that the difference between the maintenance costs for the flexible and concrete pavements was negligible. It is considered that 3 cents per square yard per year is the average maintenance cost for all pavements.

The fact that the costs were practically the same for both types of pavements appears strange, until one considers that the resealing of joints on concrete pavements is reoccurring and a costly procedure plus the fact to repair a section of concrete pavement usually requires the complete replacement of a panel, whereas a flexible type pavement may be repaired in much smaller sections.

The present planning standards for air stations provide for:

(*a*) 8,000-foot runways capable of supporting the operations of planes with a single wheel load of 20,000 pounds at 250 per square inch tire pressure or 50,000 pounds at 150 per square inch tire pressure (whichever condition is limiting) and

(*b*) 500-foot ends of the runway, parking areas, warmup pads or aprons and holding areas at junctions of taxiways and runways to be constructed of surfaces resistant to the effects of jet blast and fuel spillage, and there is presently no contemplated change in the foreseeable future.

CASE STUDIES

NAS Whidberg Island, Wash.—Contract NOy–26305, runway, taxiways and parking areas

1. The work consisted of:

(*a*) New runway 6–24: 200 feet by 8,000 feet and 9,600 feet of 75-foot wide taxiway; 40,000 square yards of parking area.

(*b*) Remove and renew existing runway and taxiway sections at intersections.

(*c*) Demolish, remove, relocate, and reconstruct buildings and utilities and fences.

(*d*) Asphalt stabilized shoulders.

(*e*) Airfield lighting, including new vault.

(*f*) Storm drains and drainage structures.

(*g*) Stripling and numbering runway and taxiways.

(*h*) The runway and taxiways are of concrete, 10 and 11 inches thick.

(*i*) Areas:

Portland cement concrete	*Square yards*
Runway	178,000
Taxiways	80,000
Parking areas	40,000
Total	298,000

2. The total cost was $4,761,044 broken down as follows:

(*a*) Clearing and grubbing, obstruction removal, and marking	$143,604
(*b*) Excavation and fill	1,020,992

Portland cement concrete—Continued

	Square yards
(*c*) Subbase materials and preparation, base courses and all completed end zones and shoulders	122,077
(*d*) Runway, taxiways, and parking paving	2,476,706
(*e*) Drainage ditches and structures	473,100
(*f*) Relocation, extension, modification, and demolition of structures and utilities	286,245
(*g*) Airfield lighting and marking (includes equipment)	238,320

3. Total area of paved surfaces, 298,000 square yards. Unit cost, $4,761,044 divided by 298,000 equals $16 per square yard.

Unit cost of concrete pavement, including only subbase, base course and wearing surface, items (*c*) and (*d*): $2,598,783 divided by 298,000 equals $9.06 per square yard.

NAS Miramar, Calif.—Contract NOy–23299, extension of runway for jet operations

1. The work consisted of:

(*a*) A 2,000-foot extension of existing concrete runway 6L–24R, 200 feet wide. The pavement for the extension is 12 inches thick and is laid on 12 inches of select subbase material. The subgrade was compacted native material.

(*b*) A 2,000-foot taxiway return 75 feet wide, 12 inches thick.

(*c*) Asphalt-treated shoulders. Shoulder widths are 75 feet for runway extension and 20 feet for taxiway.

(*d*) 1,000 by 1,500 feet graded end zone.

(*e*) Airfield lighting (high intensity) for entire runway 6L–24R and taxiway return.

(*f*) Water and gaslines under runway and taxiway extension.

(*g*) Concrete drain pipes and structures.

(*h*) Site clearing and grading.

(*i*) Stripping and numbering runway.

(*j*) Areas.

Portland cement concrete

	Square yards
Runway extension	45,000
Taxiway	21,000
Total	66,000

2. Total cost was $1,024,155, broken down as follows:

(*a*) Clearing and grubbing, and obstructions, removal, and marking	$27,167
(*b*) Excavation and fill	116,680
(*c*) Subbase materials and preparation, base courses, and all completed end zones and shoulder work	254,329
(*d*) Runway and taxiway paving	370,060
(*e*) Drainage ditches and structures	45,123
(*f*) Utilities and other extensions and relocation	22,929
(*g*) Runway, taxiway, and parking lighting and marking (includes equipment)	185,867

3. Total area of paved surfaces, 66,000 square yards. Unit cost $1,024,155 divided by 66, equals $15.50 per square yard.

Unit cost of concrete pavements including subbase and wearing surface, items (*c*) and (*d*): $624,389 divided by 66,000, equals $9.47 per square yard for (12 inch concrete and 12 inch subbase)

NAS Cecil Field, Fla.—Contract NOy–27261, construction of runways, taxiways, and parking apron

1. The work consisted of—

(*a*) Parallel north-south runways: No. 18L–36R, 8,000 feet long by 200 feet wide; No. 18R–36L, 8,000 feet long by 200 feet wide.

East-west runway: No. 9–27, 8,000 feet long by 200 feet wide.

North-south taxiway, 8,000 feet long by 75 feet wide parallel to runway 18R–36L.

East-west taxiway, 8,000 feet long by 75 feet wide parallel to runway 9–27.

Aircraft parking apron: 2,900 feet by 600 feet parallel to N-S taxiway; 300 feet by 550 feet north of new hangar.

(Total: 236,100 square yards: 400 feet by 550 feet south of new hangar.)

(b) Type of Construction:

1. Runways: 500 feet at each end is 10 inches portland cement concrete on 6 inches stabilized subbase (4 inches sand, 2 inches lime rock compacted) on compacted subgrade. Interior 7,000 feet is 3 inches bituminous surface laid on 9 inches compacted lime-rock base primed with cutback asphalt and placed on 6 inches stabilized subbase (4 inches sand, 2 inches lime rock) compacted on a compacted subgrade. Runway shoulders are stabilized for 50 feet from edge of pavement on each side. Material used for stabilization is material salvaged from abandoned runway mat.

2. North-south taxiway: 6,900 feet of 10 inches portland cement concrete on 6 inches stabilized subbase (4 inches sand, 2 inches lime rock compacted) on compacted subgrade. 1,100 feet (crossing runway 9–27 and proposed parallel runway) is 3 inches bituminous on 9 inches compacted lime-rock base primed with cutback asphalt and laced on 6 inches stabilized subbase (4 inches sand, 2 inches lime rock) compacted on a compacted subgrade.

East-west taxiway same as north-south taxiway except that the asphaltic concrete section of 1,100 feet crosses runways 18L–36R and 18R–36L.

3. End zone for runways are stabilized 1,000 feet long by 300 feet wide with salvaged material.

4. Aircraft parking apron: 10 inches portland cement concrete on 6 inches stabilized subbase (4 inches sand, 2 inches lime rock) compacted on a compacted subgrade.

2. Total cost broken down as follows:

(*a*) Site preparation (clearing, etc.)	$ 608,870
(*b*) Grading, excavation, and so forth	1,204,220
(*c*) Subbase, material and preparation base course, shoulder work	1,286,818
(*d*) Runway, taxiway, and parking paving	3,302,655
(*e*) Storm drainage	1,278,059
(*f*) Relocated road and miscellaneous work	109,064
(*g*) Field lighting and marking (including equipment)	628,573
	8,418,259

3. Total cost contract, $8,266,259; total cost lighting materials, $152,000; grand total, $8,418,259.

Quantities

	Square yards
Runways (3)	538,815
Taxiways (2)	207,991
Parking area	236,100
Total	982,906

Unit cost: $8,418,259 divided by 982,906, equals $8.56 per square yard.

4. Cost breakdown for pavement including only the subbase, base course and surfacing:

482,100 square yards, portland cement concrete, (10 inches concrete and 6 inches subbase) equals 16 inches; $9.61 per square yard.

500,806 square yards asphaltic concrete (3 inches asphalt surface and 9 inches base and 6 inches subbase), equals 18 inches; $7.53 per square yard.

NAAS-NAOTS Chincoteague, Va.—Contract NOy–75769, extension to runway 4–22, parallel taxiway, and additional parking apron.

Existing runway: Portland cement concrete pavement (6 inches thick) 150 feet wide by 5,100 feet long.

Existing taxiway: Portland cement concrete pavement (8 inches thick) 75 feet wide by 5,100 feet long.

Scope new work: Abandon 750 feet of north end runway and use for part of end zone, and construct 150 feet 10 inches reinforced Portland cement concrete, holding area to connect taxiway to 22 end of runway.

Extend 4 end of runway 3,650 feet by 150 feet wide: (*a*) 3,150 feet by 150 feet section is flexible pavement having 1½ inches wearing surface, 1½ inches binder course, 9 inches base course, 9 inches subbase, and 12 subgrade in fill or 8 inches subgrade in cut. (*b*) 500 feet by 150 feet section at end is reinforced Portland cement concrete 10 inches thick on 6 inches subbase on 12 inches subgrade in fill or 8 inches subgrate in cut.

Extend parallel taxiway 3,950 feet by 75 feet 3,450 feet by 75 feet section flexible pavement same as runway, (*a*) above. 500 feet at end and 150 feet

holding area from taxiway to runway is same as end of runway, (*b*) above.

Parking apron 1,250 feet by 360 feet with three 75-foot by 250-foot connections to taxiway. 10-foot nonreinforced Portland cement concrete on 6 inches subbase on 12 inches subgrade in fill or 8 inches subgrade in cut.

	Square yards
Concrete parking apron	56,500
Concrete at 4 end of runway	12,430
Concrete at 22 end of runway	5,500
Concrete connecting taxiway to runway	4,360
Total	78,790

Unit cost per square yard, equals $9.32 including drainage, structures, and lighting.

	Square yards
Asphaltic concrete (runway)	52,500
Asphaltic concrete (taxiway)	28,750
Total	81,250

Unit cost per square yard equal $7.81 including drainage, structures, and lighting.

Cost of pavement and supporting materials only:

	Per square yard
Concrete	$6.79
Asphalt	5.28

Total thickness asphaltic concrete pavement (3 inches surface, plus 9 inches base, plus 9 inches subbase) equals 21 inches.

Total thickness Portland cement concrete, pavement (10 inches concrete plus 6 inches subbase) equals 16 inches.

NAS Brunswick, Maine.—Contract NOy–26071, runway 1R–19L, taxiway and parking areas.

1. The work consisted of—

(*a*) A new runway 200 feet wide and 8,000 feet long. The center 7,000 feet is 3 inches asphaltic concrete on 17 inches of selected base material. Subgrade is compacted local material. Shoulders are 150 feet wide and consists of 20 inches of compacted local material with penetration asphalt treatment. 1000 feet Portland cement concrete runway 10 inches thick on 9 inches of select base material.

(*b*) 10,675 feet of asphaltic concrete taxiway and 1,000 feet of Portland cement concrete taxiway 75 feet wide with 25-foot shoulders. Construction same as runway.

(*c*) 116,500 square yards of Portland cement concrete parking area of same construction as runway.

(*d*) 12,616 square yards of holding area at ends of runway. Portland concrete cement with same construction as runway.

(*e*) Graded end zones 1,000 feet long by 1,500 feet wide.

(*f*) Drainage ditches and structures.

(*g*) Striping and numbering runway and taxiways.

(*h*) Airfield lighting.

(*i*) Areas:

	Square yards
Portland cement concrete:	
Runway	22,222
Taxiway	8,333
Parking area	116,150
Holding areas	12,616
	159,321
Asphaltic concrete:	
Runway	117,777
Taxiway	88,960
	266,737
Grand total	426,058

2. Total cost $4,402,470, broken down as follows:

(a) Clearing and grubbing	$137,900
(b) Excavation	643,400
(c) Fine grading	52,660
(d) Base material	152,900
(e) Selected backfill	260,000
(f) Trench excavation	65,000
(g) Excavation for structures	32,000
(h) Removal of soil cement	42,900
(i) Crushed stone base	504,600
(j) Concrete pavement	1,003,230
(k) Pavement reinforcing	26,670
(l) Contraction joints	40,000
(m) Expansion joints	15,000
(n) Asphaltic concrete	386,000
(o) Stabilized shoulders	62,000
(p) Reinf. concrete structures	345,400
(q) Riprap	7,150
(r) Underdrain structures	36,720
(s) Small and medium drain pipe	59,190
(t) Large drain pipe (66 inch, 72 inch)	219,500
(u) Placing large drain pipe	33,360
(v) Painting	13,720
(w) Asphalt for priming and sealing	30,360
(x) Loam and mulch	213,500
(y) Tie-down anchors	19,710

3. Total paved area, 426,058 square yards. Unit cost, $4,402,470, divided by 426,058 equals $10.33 per square yard.

The contract was based on a lump sum bid and the bid items were such that no distinction can be made between cost of asphaltic concrete and portland cement concrete. However, a change order for using asphaltic concrete in lieu of portlant cement concrete in certain areas indicated that the contractor considered asphaltic concrete to be $3,37 cheaper than portland cement concrete.

Portland cement concrete pavement equals 10 inches concrete plus 9 inches base, equaling 19 inches.

Asphaltic concrete pavement equals 3 inches asphaltic plus 17 inches of base, equaling 20 inches.

NAS Port Lyantey, French Morocco.—Portland cement concrete runway (this was a CPFF contract and costs cover 1951–52).

a. Type of facility.

(1) Runways and taxiways, 11 inches Portland cement concrete on 12 inches prepared base composed of quarry run sandstone with 10 inches local clay as binder compacted in place on a subbase, averaging 60 inches, of local clay with fines from sandstone quarry.

(b) Cost of runway if $3,097,500.

(c) Unit costs.

(1) Quantities: Runway (8,000 feet by 200 feet) equals 178,000 square yards.

(2) Unit cost if $17.40 per square yard.

(3) Unit cost allowing for extra fill: Average fill per square yard, is 6 feet or 2 cubic yards per square yard. Cost per cubic yard of fill equals $3 or $6 per square yard. Concrete pavement equals $11.40 per square yard, which includes drainage but does not include A. and E., Bureau reservation or lighting.

Runway lighting equals $115,300 or $0.65 per square yard of runway.

DEPARTMENT OF THE AIR FORCE,
OFFICE OF THE SECRETARY,
Washington, May 1, 1953.

Hon. DEWEY SHORT,
Chairman, Committee on Armed Services, House of Representatives.

DEAR MR. CHAIRMAN: Your recent letter requested a detailed analysis of a document entitled "Military Airfield Construction—United States Air Force 'Criteria' and 'Policies'" which dealt with the comparative merits and costs of portland cement concrete and asphaltic concrete pavements.

I shall discuss the points raised in the same order that they appear in the document which you forwarded as an enclosure to your letter.

At the time the Air Force embarked on the large-scale construction program, knowledge of pavement performance under jet aircraft usage was very limited. As the number of jet aircraft increased there was a resultant increase in questionable asphaltic pavement performance due to the effects of jet fuel spillage, heat and blast. It became apparent that the Air Force, with a goal of 100 percent conversion to jet aircraft, could not accept the risk involved in continuing to lay extensive areas of asphaltic pavement for long term use on permanent bases when the behavior of that type of pavement under jet operations was being questioned. Confronted with cost problems it was the decision of the Air Force to revise the criteria to the extent that, in sensitive areas on permanent installations, portland cement concrete is specified. These areas include: aprons (fueling, maintenance, parking, etc.), 1,000 feet at ends of runways, warm-up pads, wash racks and calibration platforms. Pavement for taxiways and runways (except 1,000 feet at each end), is selected on the first cost basis. At semipermanent installations the first cost principle applies to all pavements, except wash racks and calibration platforms. By designating sensitive areas for cement concrete construction and allowing the contracting industry to bid competitively on the other use-areas at permanent installations, and on all areas at semipermanent installations, the Air Force maintains the type of competition that protects the public interest and assures the Air Force a satisfactory facility at a reasonable cost. The Air Force subscribes to the procedure for taking alternate bids in geographical areas of the United Sates where flexible and rigid pavement construction is reasonably competitive.

The statements regarding the percentages of asphaltic and concrete pavements are not contradictory. The 85 percent figure referred to the total yardage of flexible pavement in existence within the Air Force at the beginning of the current large-scale program. Of the total pavement yardages on which awards were made in the first 18 months of the current construction program 40 percent was rigid and 60 percent was flexible and the contract cost for each was approximately equal.

An examination of the contract bids listed in the memorandum (some of which are inaccurate) indicates that, with one exception, the differential between rigid and flexible pavement was considerably below 20 percent. At Smoky Hill Air Force Base the low bids, including all items, were $2,049,857.80 and $2,048,958 for rigid and flexible pavement respectively; a difference of $890.80. At McGhee-Tyson Air Force Base, used jointly by the Air Force and the city, a decision had been made by the Air Force to award on the basis of flexible pavement. The city officials, objecting to flexible pavement, made up the difference of $138,000 to obtain concrete and subsequently contract was awarded for concrete. At Forbes Air Force Base there was a 4 percent differential and at Lincoln Air Force Base a 3 percent differential. At both bases rigid pavement was selected as an exception to the original criteria, but in line with criteria revisions then being proposed. The low bid for rigid pavement at Carswell Air Force Base was $2,423,000 instead of $2,604,361 as listed; however, award was made on a contract bid of $2,380,988 which included both rigid (runway) and flexible (taxiway) pavement. At McClellan Air Force Base the differential amounted to approximately 33 percent; however, the decision to accept portland cement concrete was based on the fact that the particular apron area in question, located adjacent to the maintenance hangars, is devoted entirely to the same type of maintenance as that conducted on the hangar floor. Under these conditions portland cement concrete is a functional requirement. The project at Mitchel Air Force Base, to which reference is made, never progressed beyond the proposal stage; accordingly, no award was made and therefore estimated saving is questionable.

McGuire Air Force Base was originally designated a semipermanent installation and, in accordance with criteria, the Office of the Chief of Engineers was directed to design for flexible pavement; however, prior to approval of final plans this installation was designated as permanent and design criteria were changed accordingly.

Every instance of damaged asphaltic pavement was reported by the Air Force commanders and I am informed that members of the Asphalt Institute are familiar with each instance. Principal cause of damage was jet fuel spillage and jet blast. The extent of damage ranged from superficial to major failure. These reports were the basis of the statement that "performance of asphaltic pavement has not been as good as uniformly expected." Under these circumstances the Air Force had no alternative but to take measures to reduce causes of damage by increasing "housekeeping" effort in order to protect its invest-

ment. In the case at Pinecastle Air Force Base these measures did not restore the damaged areas to its former condition as stated in the memorandum. The fact of the matter is that after several months the material in the damaged areas can be easily dislodged. The Air Force cannot afford to construct facilities in which expensive maintenance and housekeeping problems are inherent. This is especially true during an emergency when it would become necessary to divert manpower for abnormal pavement maintenance (other than that caused by enemy action) in order to keep these facilities fully operational.

The statement that 35,000,000 square yards of airfield pavement are included in this year's program for the Zone of Interior is correct. Had the Air Force elected to apply the revised criteria to all Zone of Interior installations 20,000,000 square yards would have been concrete. Instead, the criteria was applied to only permanent installations involving a total of 9,000,000 square yards.

The Air Force has neither intended nor inferred that construction be halted pending the outcome of current research and investigation of improved pavement types. The Air Force has sponsored considerable research to improve pavement types, however, it should be recognized that the 143 wing Air Force cannot be jeopardized by halting construction pending completion of such research.

The Air Force has been considering the application of the revised criteria of August 19, 1952, to semipermanent bases, however, no directive changing present criteria has been issued to the Chief of Engineers.

At the time the revised criteria were being considered, the Air Force was well aware of the additional cost involved. As a matter of fact, had the original criteria remained in effect, the initial cost would be some $20 million less rather than $10 million. It is realized that the least expensive construction is not being utilized, however, we are convinced that the revised criteria provide a facility which more nearly meets Air Force requirements.

The statement that only 10 percent of the area of airfield pavement can be considered critical is not borne out by the facts during years of experience by the Air Force in ground operations of aircraft. The types of aircraft and method of handling are constantly changing, and it is, therefore, a fallacy to believe that certain operations will be conducted in specified areas.

Although instructions concerning application of the revised criteria, as published, refer only to permanent installations in the zone of interior, the criteria are also being applied to designated permanent overseas installations. Furthermore, the Air Force still retains in effect a long-standing policy which permits construction of concrete pavement at other overseas installations where adequate control cannot be maintained to assure the specified high quality asphaltic pavement.

Recently Under Secretary Douglas and other Air Force officials met with representatives of the asphaltic concrete industry for the purpose of considering the divergent views on the subject of portland cement concrete versus asphaltic concrete pavements. This Department will continue to cooperate closely with industry on this matter to insure pavement construction at minimum cost that will meet Air Force requirements.

Sincerely yours,

GLENN E. DUNCAN,
Colonel, USAF

(For and in the absence of Robert E. L. Eaton, Major General USAF, Director, Legislation and Liaison).

Enclosure

DEPARTMENT OF THE AIR FORCE,
OFFICE OF THE SECRETARY,
Washington, July 6, 1953.

Hon. WILLIAM E. HESS,
Chairman, Subcommittee on Defense Activities,
Committee on Armed Services, House of Representatives.

DEAR MR. CHAIRMAN: I am glad to respond to your letter of May 29, in which you requested information on the subject of Air Force construction.

In 1950, when the Air Force entered into an expanded construction program, careful consideration was given to the question of airfield pavement types. One factor that was considered was the effect of jet aircraft operations on these airfield pavement types. Based on our own observation of limited jet

aircraft use and upon assurances from the Army Corps of Engineers (the Air Force construction agent) that a design for asphaltic concrete pavement had been perfected which would provide an adequate pavement for jet propelled aircraft, the Air Force adopted the policy of accepting either Portland cement concrete pavement or asphaltic concrete pavement for airfield construction based on the lowest first cost.

By mid-1952, certain new airfield pavement had been subject to traffic by jet aircraft. No difficulty had been reported with new Portland cement concrete pavement. The performance of asphaltic concrete pavement had varied from good to complete failure. At Lockbourne Air Force Base, the asphaltic apron is today still giving excellent service. At Williams Air Force Base, the asphaltic apron was a complete failure. In addition to damage to asphaltic pavement on which aircraft are normally parked, evidence was accumulating on burns and erosion of runways ends resulting from jet aircraft operation. Because of this evidence, the Air Force position in July 1952, was subjected to formal review by the Installations Board, an Air Force staff agency concerned with airbase construction criteria.

In the face of steadily increasing jet operations with new and more powerful engines and because of increasing uneasiness of field commanders, the Air Staff felt that an element of risk existed in the strict application of the first-cost principle. Despite this and in view of the higher first cost of concrete over asphaltic pavement, the Installations Board decided to accept a calculated risk for the fiscal year 1953 paving program at the semipermanent bases in the United States and the indeterminate-use bases overseas. At the permanent bases in the United States concrete runway ends and aprons were prescribed. In addition, the Board directed increased observation and experimental projects to permit a review of their decision at the earliest possible date. When all this data has been received and analyzed along with the knowledge that damage to asphaltic concrete continues to occur in certain cases and that a premium must be paid for portland cement concrete, then it is hoped that the reevaluation of the Air Force position which is now in progress can be concluded.

In our letter of September 2, 1952, it was stated that in the prior 18 months the division between asphalt and concrete had been 60–40 and the dollar cost of the two types had been approximately the same. What was meant was that the ratio of the quantity of asphalt pavement to concrete pavement, for which awards were made, was 60–40. The total cost of the asphalt pavement was approximately equal to the total cost for the concrete, which means that on a unit basis the cost of concrete is approximately one and one-half times the cost of asphalt. More recent figures received from our major construction agent reveal that from January 1, 1951, to October 30, 1952, contract awards were made on a total of 21,098,549 square yards of pavement of which 53 percent were for asphalt and 47 percent were for concrete.

On the matter of maintenance costs the records of world wide average expenditures do not indicate any significant cost differential per square yard between the two types of pavement. It must be stated, however, that to date only a small percent of our active aircraft is jet propelled. By fiscal year 1957, it is anticipated that 50 percent of the active aircraft will be jet propelled. Jet propelled aircraft impose two potentials for airfield pavement damage not imposed by conventional aircraft. One potential is jet blast, with its high temperatures and velocity. The second is the spillage of raw jet fuel on asphaltic parking areas during fueling, and other ground operation periods. This spilled fuel, while not incompatible with portland cement concrete has a most harmful potential where asphalt is concerned because of the solubility of asphalt in petroleum derivatives.

From the standpoint of ground handling of aircraft, no difficulties have been encountered. Either portland concrete or high quality asphaltic concrete or a combination of the two has proven generally acceptable to the Air Force.

Personnel have been apprised of the pending committee hearing and will be prepared to answer with specific data questions posed by the subcommittee.

I trust that this information will be of assistance to your committee.

Sincerely yours,

ROBERT E. L. EATON,
Major General, USAF,
Director, Legislative Liaison.

JANUARY 8, 1954.

Subject: Airfield Pavement Criteria and Alternate Bid Schedules for Air Force Installations (Uncl).

To: Office, Chief of Engineers, Department of the Army, Washington, D. C.

From: Chief, Bureau of Yards and Docks, Department of the Navy, Washington, D. C.

1. Letter, this headquarters, dated August 19, 1952, subject: "Criteria for Airfield Pavement Construction at Air Force Installations," and other correspondence in conflict with criteria set forth below are hereby rescinded.

2. Criteria:

(*a*) Critical areas: The following airfield pavement areas will be constructed of portland cement concrete:

(1) All apron areas including access ramps to hangars or docks.

(2) Stub parking (hardstands).

(3) Washracks.

(4) Calibration platforms.

(5) Warmup pads.

(6) Runway ends (1,000 feet).

(*b*) Noncritical areas. All other airfield pavement areas subject to aircraft traffic, including but not restricted to runways (except end 1,000 feet) and taxiways, will be constructed of either portland cement concrete or high-density asphaltic concrete, depending on the evaluation of various factors, such as quality of existing subgrade and the relative costs of the alternate types of surface. Decision as to type of material for noncritical areas will be made in accordance with procedures outlined in paragraph 3 below.

3. Procedure for invitations for bids, alternate bid schedules and contract award.

In accordance with the above-stated criteria:

(*a*) The contracting officer will make control estimates, following determination of subgrade condition, to establish the comparative costs of the pavement project using all concrete pavement versus a combination of portland cement concrete pavements in critical areas and asphaltic concrete pavement in noncritical areas. (The pavement project is defined as the airfield pavement line item or line items, being included in the particular invitation to bid.)

(*b*) If the spread in control estimate exceeds 15 percent, plans and specifications will be prepared only for the combination type of construction involving both portland cement concrete (critical areas) and asphaltic concrete (noncritical) areas. Award of contract will be made by the construction agency, based on lowest responsive bid.

(*c*) If the spread in control estimate cost is 15 percent or less, plans and specifications and bidding schedule will be prepared for:

(1) All portland cement concrete, and

(2) A combination of portland cement concrete and asphaltic concrete, in accordance with the criteria in paragraph 2, above.

Bids will be invited for both schedules. If evaluation of bids for the pavement project reveals a spread in costs of 5 percent or less between the competitive pavements, award of contract will be made by the construction agency to the lowest responsive bidder for all portland cement concrete. If evaluation of the bids for the pavement project reveals a spread in cost in excess of 5 percent between the competitive pavements, award of contract will be made by the construction agency to the lowest responsive bidder.

4. At installations where extensions to existing runways are authorized:

(*a*) If the extension is 1,000 feet or less in length, portland cement concrete will be used.

(*b*) If the extension exceeds 1,000 feet in length, the end 1,000 feet will be of portland cement concrete pavement. The pavement for the intervening area between the end 1,000 feet and the existing runway shall be designed and constructed to match existing adjacent pavement in material and strength. However, in cases where the adjacent pavement is of asphaltic concrete, and the control estimates, considering the requirement for different construction plants, indicate that it would be as economical to use only portland cement concrete, the entire extension will be of portland cement concrete.

5. When alternate bids are invited, bidding information to contractors will include statements that the Government reserves the right to award on the basis of portland cement concrete where the lowest responsive bid for an all concrete pavement project is within 5 percent of the lowest responsive bid for a combination type pavement project.

6. Should it be determined that design or advertisement of any pavement project has progressed to a point where application of the above criteria would result in undue delay, the Air Force installations representative is authorized to grant an appropriate waiver.

7. Deviations from the criteria set forth above which may be due to special unforseeable conditions will be prescribed in the design directive.

For the Chief of Staff:

LEE B. WASHBOURNE,
Major General, USAF,
Assistant Deputy Chief of Staff, Operations.

MR. JOHN J. COURTNEY,
Special Counsel, Committee on Armed Services,
Subcommittee on Defense Activities, House Office Building,
Washington 25, D. C.

DEAR MR. COURTNEY: Your invitation to submit testimony before your subcommittee on the relative cost, suitability, and availability of cement concrete and asphalt for airfield pavement is greatly appreciated but we feel that we are not in position to give the committee anything of value on this subject.

Both materials are exceedingly useful and it appears that they are generally available in abundance almost everywhere that they might be needed. There are, however, so many circumstances and combinations of circumstances which govern an engineer in making his decisions as to which should be used on a given project that it is manifestly impractical to lay down any hard and fast rules. Each project requires careful study and analysis in order to make an intelligent selection of the proper materials to be used. It is therefore clear that we are not in position to accept your kind invitation to testify at this time.

Very sincerely,

B. L. KNOWLES,
Engineer Adviser.

Mr. RIVERS. Mr. Chairman, in that connection, concerning those enclosures from the Air Force and from the Army Engineers, or whomever can give us the information, do they have a typical example of an asphalt runway which has been used by jets and which indicates a disintegration as a result of spillage and blasts which cause the additional deterioration of the runway?

I have in mind, when I was in Morocco, 2 or 3 years ago, I visited the airbase at Sidi Slemane and there they pointed out the blasts from certain of these jets, and that there was a disintegration, that the planes were shot out and as a result of the blast there was deterioration.

Do we have something in the record showing one of these runways which has been almost exclusively used by jets which shows what will happen in the future if we continue to use asphalt and unless the answer is found by American industry?

Mr. COURTNEY. In answer to that question, we will have the Department of Air Force here, Mr. Rivers, and of course the questioning will relate to the establishment of criteria. That, of course, will have to do with their experiences, and the specific instances on which they found their criteria.

Mr. RIVERS. They may have a longevity of 5 or 10 years.

Mr. COURTNEY. That, of course, will have to be developed.

Mr. Chairman, we have invited here the Association of General Contractors and they, of course, have said that their interest is not with the establishment of criteria, but with the performance of the work and felt that they couldn't make any contribution to our under standing of the problem there.

Mr. HESS. Could not, you say?

Mr. COURTNEY. Yes.

We have invited the Portland Cement Association and the Asphalt Institute of America; and there have also been invited representatives of the United States Rubber Co. and the Flintcote Corp., both of whom have technical interests in the proceedings, and at some time or other may be able to make a contribution toward our understanding of the problem.

To get this thing off we have asked the Asphalt Institute to come here this morning. They have prepared a brochure.

Mr. Gray, who is the president of the institute, is prepared to make a presentation on their behalf.

Mr. Gray is here, Mr. Arvin S. Wellborn, their chief engineer is here, and Mr. Frank Gardner is also here, and is one of the engineers for the institute.

Preliminarily I may say that these gentlemen have spent a great deal of time in investigating the subject of damage to which Mr. Rivers made reference and adaptability of their particular material to continued use in the present state of development of the Air Force.

Now, Mr. Gray, would you like to take over?

STATEMENT OF BERNARD GRAY, PRESIDENT, THE ASPHALT INSTITUTE; ACCOMPANIED BY ARVIN S. WELLBORN, CHIEF ENGINEER; AND FRANK GARDNER, STAFF ENGINEER

Mr. GRAY. Mr. Chairman, and members of the committee; I appreciate full well that when I come before you I am to some extent pleading a special case. I trust, however, that I am also endeavoring to present facts in the situation as I see it as a good citizen.

This brochure that we have prepared is fairly voluminous. I don't propose to read but the first part which I will do in order to save time.

My name is Bernard Gray. I am president of the Asphalt Institute. With me are Messrs. Arvin S. Wellborn, chief engineer, and Frank Gardner, one of our staff engineers, who formerly, for several years, was with Headquarters Military Air Transport Service as Chief of the Grounds Section, Installation Engineering Division. In that capacity he has inspected fields here and abroad.

The Asphalt Institute is the research and engineering organization for the bulk producers of asphaltic materials. In 1953 this production was around 14 million tons. Seventy-five percent of all asphalt produced goes into paving, largely on airfields, highways, parking areas, and streets. Combined with aggregates of stone, gravel, and slag the various kinds of asphaltic surfacing placed now amount to over 200 million tons each year, and constitute by far the majority of all pavements constructed and maintained. These figures are cited to show the position now occupied by asphalt in providing the needed facilities in modern society.

The institute does not itself market any material. Its activities are directed to the development of appropriate techniques for using asphalt products to the best advantage and of making these known to the consumer. It maintains branch offices throughout the United States, staffed with engineers of long experience in paving, who are in constant touch with actual construction and maintenance operations and who give advice on how to plan new work and maintain old. In this capacity institute engineers have been associated with the

building of airfields over a long period and are well acquainted with the requirements imposed by changing service conditions.

These service conditions have undergone considerable change within a relatively short period. It was not much over 20 years ago that turf was the preferred surface for runways, and only a little while thereafter that the pavements substituted in its place had to be somewhat soft in character so that the tailskid of the planes of that period could secure an adequate hold on landing. With further substitution of tires for skids, airfield designers indicated preferance for open-textured surfaces in order to have the nonskid characteristics needed to provide safe landings. The war brought a further rapid development in size and weight of planes, but except for increase in thickness of pavements to take heavier loads, the surface characteristics desired remained about the same. Very recently has come the jet development and with it need for further revision in design and construction procedures to meet the new conditions imposed. Engineers for the several branches of the armed services, as well as civilian aviation authorities in Government, have all revised specifications accordingly.

With these rapid changes in the character of the planes, many of the early airfield pavements have required reconstruction. This is true of both the two principal types employed, asphalt and concrete. Pavements designed for 15,000-pound wheel loads were obviously inadequate for loads that now are more than 10 times as great in some instances, although the asphalt fields frequently carried successfully much heavier loads than planned for. To strengthen these old pavements and maintain operations until complete reconstruction or new fields could be obtained, there has been extensive resurfacing with asphalt over both concrete and asphalt. Such work in general has served admirably in most instances, although by reason of limited funds, the thickness of such addition was at times less than desirable.

ADVANTAGES OF ASPHALT

1. It is generally agreed that both asphalt and concrete can be designed to carry any wheel load. The method of design varies but competent engineering authority understands the principles involved and can design either type to carry the heaviest loads, whether for the standard type of tire or the newer high-pressure tire where intensity of loading is a factor as well as total load. There are several kinds of asphalt pavement designed to meet various service conditions. For military airfields, the heavy-duty hot-mix asphalt type is usually employed. Both asphalt and concrete are maintained by standard procedures that are well known.

2. Asphalt pavements in general can be constructed more rapidly than other types of pavement, because no curing period is required other than for the hot-mix, to cool to air temperatures.

3. A further advantage of asphalt, and which becomes more apparent under emergency conditions, is that a smaller weight of binder needs to be transported. This is because the principal strength of an asphalt pavement is most economically secured by using aggregate, such as crushed stone, gravel, slag, or selected soils in the foundation, and which usually are nearby to the site of the work.

This is a chart to show a typical example. This happens to be the Tye Air Force Base at Abilene, Tex., where asphalt is now being constructed.

On the left will be the asphalt section and you will notice that this compacted subbase, which is 16 to 30 inches thick, provides the lower support so that as the weight is transmitted down through the subgrade it is never overstressed.

One of the great engineering advancements in recent years has been the science of soil mechanics whereby engineers are able to select soils exactly so that they are not affected by frost and moisture, and which has had the effect of reducing the cost of material very materially.

Mr. RIVERS. What is the composite thickness of that and similar runways made of concrete?

Mr. GRAY. In this particular case, there is 21 inches of concrete and base and there is about 50 inches of the asphalt and the stone and the base which is very heavy pavement and yet it costs less money; 50 inches as against—well, 22 inches.

Mr. RIVERS. Thank you.

Mr. COURTNEY. What you are saying is that the material in the subbase below the asphaltic concrete is locally generated?

Mr. GRAY. Yes. In this particular instance only the upper 4 inches requires any commercial material in the way of a binder.

Mr. COURTNEY. Crushed stone is near the site?

Mr. GRAY. Yes.

Mr. COURTNEY. Do you know whether the jets use this Tye Air Base?

Mr. GRAY. I suppose so.

Mr. WELLBORN. This base is under construction now, Mr. Courtney.

Mr. GRAY. Thus, while there is substantial thickness of the composite pavement, the asphat wearing surface is but 3 to 5 inches thick, while a comparable design for concrete may be three times as much for the wearing layer. Just how much this variation amounts to may be seen from the fact that a heavy-duty pavement, capable of carrying the weight of the heaviest planes, requires, in the case of concrete, from 250 to 300 pounds of cement per square yard, whereas only 18 to 30 pounds of asphalt are needed. This would seem a very important item and particularly under wartime conditions where transport is so much required for all other uses.

Another important advantage of asphalt is its reaction under bombing, and something that deserves consideration in the building of any military field. By its very nature, there are no large broken fragments to be removed. Moreover, it is possible to stockpile asphalt repair mixtures in advance so that the bombed areas can be immediately replaced and under use. Thus it seems appropriate to state that under wartime conditions asphalt would be the most logical material for all advance bases for transport and repair reasons alone.

5. Asphalt pavements are free from joints, as modern placement methods insure that adjacent lanes are completely bonded together, the usual practice being to stagger the spread of each successive layer to provide an overlap. Crack filler is thus eliminated almost entirely.

6. Asphalt surfaces are free of ice and snow more quickly than other types.

7. Asphalt pavements are easier to maintain. While few records are available for airfields, showing comparison between heavy-duty

pavements, because either of the short period of use, or the need for reconstruction of earlier pavements to provide greater thickness—true of both types—its history on highways is sufficient to show the facts.

For example, a study by the Oklahoma Turnpike Authority, before selecting asphalt for the toll road in that State, indicated very clearly that costs for all heavy-duty pavements were very similar, the advantage if any being for asphalt.

Records from Massachusetts, Pennsylvania, and other States, all indicate that properly built high-type pavements cost about an equal amount per square yard to maintain. The advantage for asphalt is found in the ease and rapidity with which the work is done because of the short period required for curing.

COSTS

It being entirely possible to construct either type of pavement to meet the heaviest loading conditions, the next point to be considered would be which one costs the least to build. The best evidence in this regard is by study of the bids submitted on paving work at various locations. A representative list is shown in exhibit A attached.

It will be seen from this exhibit, that, in general, pavements of equal load carrying capacity can be constructed with asphalt at costs which are 20 percent or more under those for concrete pavements. In some instances the savings are very much more, where aggregates for foundations are cheaply available. In money, this saving in first cost is frequently several dollars per square yard, which for the huge areas involved runs to large sums. For example, at Westover Field, where the natural subgrade has very high support value, the thickness of the asphalt design permitted a bid of $2.66 per square yard as against $6.59 per square yard for portland cement. For the areas involved this could amount to a difference of nearly $3 million.

Considering these potential savings, one might naturally inquire why not all pavements to be asphalt? Why are asphalt pavements excluded or being given an unfavorable differential in bidding for different portions of the areas to be paved? It is fully recognized that cost alone might not be the sole consideration, therefore discussion of these other items is pertinent at this hearing. Jet planes do present new service conditions. They impose severe stresses on limited areas, but nothing unusual on others. Both types of pavement are affected in varying degree. Just how serious are these changed conditions, and how do they affect a pavement? They include principally fuel spillage, blast and possible movement of loose particles. They will be discussed in that order.

FUEL SPILLAGE

First it is to be noted that an asphalt pavement contains only 5 percent or 6 percent of asphalt binder, the remainder of the pavement being mineral aggregate which is not in the least affected. Consequently if the pavement is properly constructed to a dense graded condition by methods which are commonly known, the damage from spillage will be nominal in character even under the worst conditions. It is but appropriate to note here that not only asphalt pavements may be affected but that some of the acid type fuels may injure con-

crete as well. Second, spillage is limited to but very small areas of an airfield surface, the great majority of the area not being subject to spillage at all. In respect to this item of spillage, it is also appropriate to note that excessive spillage is of possible damage, not only to any type pavement, but as an invitation for fire and one that certainly should be avoided because of possible destruction of planes regardless of which type of pavement is used. This factor is apparently being recognized, because a number of planes appear to be so constructed that spillage is now very limited if it occurs at all.

The recommended present design of asphalt pavements takes into account the particular service which now must be rendered and by making the pavement a very dense mix, so that there can be little or no penetration of spilled fuel into the surface, damage is held to a minimum, and in an amount which may be repaired by nominal maintenance. Inspection after inspection has been made of pavements on which damage was reported and where construction had been accomplished in a proper manner, injury was negligible and confined to but a small portion of the entire area constructed. Such an inspection made by Mr. Wellborn of the Asphalt Institute is typical, and attached herewith as exhibit B.

Mr. COURTNEY. Will Mr. Wellborn tell us about that inspection?

Mr. GRAY. The report is attached. These small areas subject to spillage are properly termed "critical areas" and on them, of course, a pavement should be employed that is affected to the minimum degree practicable. To conclude, however, that because such limited "critical areas" may require special construction the entire airfield area should be similarly constructed, would appear to be carrying precaution to an unwarranted extreme, and one hardly in accord with sound engineering practice. Good housekeeping alone on all of the various areas will largely eliminate fuel spillage damage and of course should be done from the fire hazard standpoint regardless of the type of pavement used.

It is perhaps pertinent to note that the degree of damage is related not only to the amount spilled but to the character of the fuel itself. It is of maximum amount where the kerosene types of fuel are used. The trend of fuel development, however, appears to be toward more volatile material and such products, even when spilled in considerable amount, do not damage a pavement to the same extent as kerosene. It is also to be noted in this connection that concrete pavements require a certain amount of joint filler to take care of expansion, and that these fillers may be affected to produce even more difficulty than where an all-asphalt pavement is employed.

Mr. COURTNEY. What do you mean by that?

Mr. GRAY. They pour these joints with various types of filler, which are asphalt filler but are pure asphalt and very little or no mineral aggregate in them. There are other composite fillers, combination of rubber and asphalt, but they all can come loose and be loosened by fuel spillage. Engineers are endeavoring to change the type of areas subject to spillage so as to get rid of these joints but it is not practicable on a concrete pavement. It would seem, therefore, that such damage as occurs affects in some degree both types of pavement, but that in either case it is almost insignificant.

As might be expected in a controversy of this kind, examples of poor asphalt construction are cited. The one most frequently men-

tioned is Williams Air Base in Arizona. For some unknown reason a wrong type of asphalt pavement was constructed, which was extremely porous. The asphalt industry would not sponsor such design for the purpose, as it was unsuited for the conditions of use.

Mr. COURTNEY. Was that a matter of specification in the invitation to bid?

Mr. GRAY. I have never been able to run down what caused that. No, the specifications, I think, were proper. The pavement just simply was wrongly constructed. Whether it was a case of haste, or what it was, I don't know.

To conclude, however, that properly designed pavements would be similar in behavior, elsewhere, is hardly appropriate. Doubtless competing types also have had difficulties on occasion. At least it has been found desirable with both types to resurface on a number of occasions, and it is to be emphasized that where such errors occur, placement a proper dense asphalt surface over the first laid pavement is a simple and inexpensive procedure. Perhaps the best way to evaluate this situation in respect to spillage is by review of reports received in recent months. This is in exhibit C.

Mr. HÉBERT. Mr. Gray in that same paragraph, in your discussion with Mr. Courtney, also, you referred to construction at the Williams Base. In this prepared statement you say "design." Was it design or construction? You say you would not have sponsored the design. Mr. Courtney asked about specifications. What was it? Was it design or construction?

Mr. GRAY. I could have used perhaps either word there. As finally built, if that represented a design, it wouldn't be the design which we would recommend. If it was a construction that didn't follow the design that had been laid down, then that would be an example of bad workmanship.

Now, in general the specifications which have been established by the engineering authority building these fields, are satisfactory. They have been very carefully worked out. But every once in a while, as happens in every kind of work, apparently something went wrong. We don't know what it was. All we know is that the pavement was just like a sponge and when anything was spilled on it it was absorbed.

Mr. HÉBERT. You must have a design before you begin construction?

Mr. GRAY. Yes.

Mr. HÉBERT. Was the design good or bad?

Mr. GRAY. I would say the design is right and the construction didn't carry out the design.

Mr. HÉBERT. You say you wouldn't have approved the design.

Mr. GRAY. I see what your point is.

If you will change "design" to "construction."

Mr. HÉBERT. What do you mean? Your prepared statement says "design." Is it construction or design? Let's understand what it is. You have devoted a full sentence to that statement. "The asphalt industry would not sponsor such design for the purpose as it was unsuited for the conditions of use." You certainly can't change the word "design" to "construction" and continue that sentence. All I want to find out is the cause.

Mr. GRAY. As far as I know it was bad construction. The word should be "construction," Congressman, if you would change it.

Mr. HÉBERT. The construction was unsuited for the conditions?

Mr. GRAY. That is right, as constructed. The pavement as constructed was unsuitable.

Mr. HÉBERT. It doesn't satisfy me but I will pass it. It doesn't follow the explanation.

Mr. GRAY. I am not criticizing the basic design. The designs for these fields are basic. I mean, they are included in a general book of specifications and the same ones are used over and over again in different places. In most instances they are all right. In this particular instance—and this has been thrown up to us—the reason I cite this Williams Base, it has been thrown up to us as a bad example of asphalt construction and I have attempted to comment on it. That was extremely porous and in our judgment was not good construction, following the design that had been laid down.

Mr. HESS. Other bases had been built to the same design?

Mr. GRAY. That is right.

Mr. HESS. Had been functioning satisfactorily.

Mr. GRAY. That is the point.

Mr. RIVERS. May I inquire, Mr. Chairman, there?

You also contend that concrete, too, will disintegrate under conditions of spillage?

Mr. GRAY. Sometimes, with certain types of acid fuel.

Mr. RIVERS. Yours is not the only thing. You claim that with the proper construction, proper adherance to the specifications, and proper inspection by the inspecting authority, coupled with your bonding preventative, it can stand conditions equally as rigorous as any other type of construction?

Mr. GRAY. Except on very, very limited areas. We are not contending we are going to put an asphalt pavement under a spigot and let gasoline drop on it. Our contention is that the areas where this severe damage condition occurs is limited to some areas of the field and that they are much smaller than the areas that are demanded by the Air Force.

Mr. RIVERS. Would it require closer inspection to make the whole field similar in construction?

Mr. GRAY. I wouldn't say so. I would say that competent inspection will produce the results.

Mr. RIVERS. I see. I just wanted to get that for the record.

Mr. HÉBERT. May I pursue that? Do I understand your statement to indicate, then, that another material—in this instance concrete—would not lend itself to the constructive features of spillage?

Mr. GRAY. Would not lend itself.

Mr. HÉBERT. Do I make myself clear? You are talking about the limited space.

Mr. GRAY. Yes.

Mr. HÉBERT. Now, construction in that limited space can eliminate the deterioration or damage to the pavement through spillage?

Mr. GRAY. That is right.

Mr. HÉBERT. And you contend that because a certain treatment or certain construction must admittedly be conducted in that limited area, which is more expensive than the whole area, therefore the whole area should not be constructed in such a superior manner because of that limited area?

Mr. GRAY. Yes.

Mr. HÉBERT. You are not indicating that concrete could be used to better advantage than asphalt there, are you?

Mr. GRAY. I don't know as I follow you.

Mr. HÉBERT. In other words, you are talking about the limited area in following through on the ultimate conclusion, the use of asphalt.

Mr. GRAY. That is right.

Mr. HÉBERT. You are not indicating that concrete would be a better substitute there?

Mr. GRAY. Oh, I think there are limited areas where concrete would be superior. I am not contending that asphalt should be used anywhere and everywhere, not by any means.

Mr. HÉBERT. You are contending, then, concrete or a better grade of asphalt, which is of higher cost, in the limited area, should not be the formula for the entire area?

Mr. GRAY. That is right. That is the point exactly. In other words, it is a similar condition as we had around gasoline pumps when we started paving gas stations with asphalt. We were enthusiastic, and paved the asphalt right up to the pump.

We discovered that wasn't good, so we put 2 or 3 feet of concrete around the pump but paved the rest of the area with asphalt that cost less money.

That is what I am arguing for on the airfields.

Mr. FISHER. You are referring to the parking area and the area where the planes warm up before they actually get in motion in the takeoff? Is that the area that you refer to?

Mr. GRAY. I think some of those areas are paved with a higher cost material than is strictly necessary, even on aprons. They are incidental but the positions of the aprons that are subjected to this severe condition is only a small part of the total apron.

Mr. FISHER. In other words, the limited area to which you referred a number of times, by that you are referring to the aprons.

Mr. GRAY. Not the entire apron, no. Portions of them.

Mr. FISHER. Will you elaborate on what you mean by the "limited area?"

Mr. GRAY. Well, let me say it this way: Not over 10 percent, in our judgment of the area of an airfield needs to be paved with anything except the lowest cost material that you can put on it. There might be times when concrete would be less expensive than asphalt. I wouldn't have any argument about that. If they can beat the price of a properly designed asphalt pavement they should have the business, but contrarywise, I believe that if asphalt material, or any other material, which may come along, we just happen to have these two principal materials today, but if whatever material will serve the purpose, I contend that it should be used if it costs less than the competing material, and not over 10 percent.

Mr. HESS. Satisfactory, of course, for the use.

Mr. GRAY. Yes. That is a fundamental engineering principle.

Mr. NELSON. Mr. Gray, I would like to carry your argument on spillage a little further, to make sure I understand it. You say that if spillage is going to occur in quantity that perhaps concrete is better than asphalt?

Mr. GRAY. It might be in small areas.

Mr. NELSON. But you also say that spillage is unnecessary, and dangerous.

Mr. GRAY. I think it is. I have been on fields where I was scared somebody was going to drop a match.

Mr. NELSON. Would you have the committee believe that it might be cheaper in many instances to eliminate spillage than it is to build concrete runways and the rest of it?

Mr. GRAY. I won't go to the full extent of saying I would build all of the fueling areas with asphalt, although right now there are investigations being made into ways of providing a very thin treatment over asphalt pavements so that they will be immune to spillage but we have watched this spillage in gas stations for years—we have had places where tanks blew up and spilled over the whole place with hundreds and hundreds of gallons. It evaporated away and you couldn't see the difference, in the pavement.

On fields that we have been on, we have seen where there was reported spillage. There are only a few square yards out of hundreds of thousands of square yards and moreover when the spillage or the fastening of the plane at that place moved to another place, the place where it appeared to soften a little had held up and was as firm and sound as the rest of the pavement.

In other words, the point I make is that at the worst the areas that require paving with other than the most economical material are not over 10 percent of the entire airfield area.

Mr. NELSON. Isn't it true that the Navy in training carrier based mechanics and crews can't afford to have any spillage at all?

Mr. GRAY. I am not an expert on that. I would prefer to have competent authority to answer that question.

Mr. CUNNINGHAM. I am concerned how you could determine on an airfield what part the spillage is apt to be on?

Mr. GRAY. I think the pattern develops itself rather quickly.

Mr. CUNNINGHAM. There is one other question that worries me. I come from a town or city in the Midwest where for many years the streets have largely been paved with asphalt. I must say they make good streets, nice to drive on.

However, in the summertime when the temperature gets close to a hundred I notice they are spongy when you walk on them. I have seen parked cars where the wheels have dropped several inches down into the paving on warm days. A heavy airplane landing on an asphalt runway, warm weather, soft, that wheel drops in there a few inches could cause that plane to tip over.

I am wondering what your answer is to that and this further question:

I have seen some of these jets catapulted off the carriers, the deck of the carrier composed of steel almost red hot, turn the hose on it, before the next one goes up.

What will be the resistance of asphalt runways to that kind of heat, compared with the cement runway?

Mr. GRAY. I thought I would come to that in just a minute but to answer your first question:

The design of a pavement to resist any force applied to it, is something that is very well understood. In other words, if you have a light load, then a pavement can have what we call a certain stability. If it is going to be subject to very severe loads then it has got to have a much higher stability. There are laboratory methods for appraising that.

Mr. CUNNINGHAM. Maybe I can put the question this way:

Are you able to produce asphalt that will resist heat, so that it would not cause a depression with the wheel going over, cause dips?

Mr. GRAY. Yes.

Mr. CUNNINGHAM. What I am concerned about is an accident. These planes are expensive. The cost of one plane and a few lives is much more than the difference between the cost of asphalt and concrete per square yard.

Mr. GRAY. That is right. I would agree with you except that it is perfectly possible and common everyday procedure to design these pavements to take any load or any of the surface conditions that are now imposed on them.

Mr. CUNNINGHAM. What about the question of pockets? I have noticed in my hometown, asphalt and cement men have been fighting out there for 30 years in every city election. I have noticed these pavements. In spite of everything, there will be pockets, there will be a place that becomes spongy. The wheels of the car drops into it several inches. Can you guarantee against that sort of thing on an airfield? That one drop is all that is necessary with a heavy bomber coming in there.

Mr. GRAY. Well, I can answer that this way, that where these fields have been constructed with due regard to everyday engineering operations, you can walk over them from one end to the other and I think you will find that they are in very good condition.

If you go to Baltimore, for example, one of our very big asphalt airfields, you can walk down the full length of the runways and see how firm they are.

One of our problems in cities, and I think is the cause of much of what you have mentioned—is the continued digging up of the city streets to replace pipelines, etc., then they throw back the material and the next you know you have got a dip there where the trench has settled.

That is a common occurrence in every city. That is not the fault of the pavement.

Mr. CUNNINGHAM. I have personally walked on them where one part is spongy and maybe the rest would be solid. It seems to me that those spongy places appear quite frequently. If that is caused by heat, what would the jet plane do to an asphalt runway? My concern is with the lives of our boys and the saving of planes.

Mr. GRAY. That is right. I hope I am concerned likewise.

Mr. NELSON. Mr. Chairman.

Mr. HESS. Mr. Nelson.

Mr. NELSON. Mr. Gray, your institute keeps pretty good records on performance of aphalt runways?

Mr. GRAY. We try to.

Mr. NELSON. Do you have any record of any destruction of planes caused by asphalt?

Mr. GRAY. Not that I know of, at any time, that was caused by the fault of the pavement.

Mr. HESS. Proceed, Mr. Gray.

Let's let Mr. Gray finish his statement.

Mr. GRAY. The second item has to do with damage from blast. While at first this was anticipated to be of considerable amount, actual experience demonstrates that it is also limited in areas affected.

Various studies made by governmental investigators and others indicates that with the newer type of planes, impingement of the blast does not cause serious harmful reaction except in small areas where planes may be tied down for testing and repair.

In respect to the size of so-called critical areas established it is interesting to note that they are not the same in different locations. Observations on a number of fields showed runways constructed in some cases with 500-foot concrete ends, others with 1,000 feet, while in others none was used at all. There are a sufficient number of fields under heavy jet traffic to indicate that only a short section at most needs to be included as critical in respect to pavement type. These fields have been in service for a considerable period of time and are constructed with the present recommended type of hot-mix asphalt having high density. They show little or no effect from this intensive use by the most modern types of jet plane, the dark areas being superficially blackened from the blast rather than any erosion.

A third item that has been raised in respect to the two types of pavement has been the claim that there could be damage to the jet engine by reason of loose aggregate. It can be stated positively that there is no reason for loose aggregate being present on a properly constructed asphalt pavement any more than on any other type. Loose material comes on aprons or runways in large degree from extraneous sources. It may be windblown, it may be carried in from the wheels of the plane from unpaved outlying areas, or it may come from loose material left on the surface which should have been removed at the conclusion of construction. There is as much loose material present on a concrete pavement as on a properly designed asphalt pavement. It is to be remembered that damage can occur to any kind of pavement, and with the vast extent of runway areas it is not uncommon for joints in concrete to spall and break off and for the filler material in the joints to come loose. It is fair to say that so far as loose aggregate is concerned, as coming from an asphalt pavement, there is absolutely no reason why this should be present, any more than on any other kind of surface. Moreover, the dense graded asphalt recommended for airfield paving contains particles of such a small maximum size, that there is little chance of damaging a jet engine.

Restrictions on asphalt:

However, because of these various items, the Air Force has elected to gradually extend the so-called critical areas until they now often constitute the larger part of the airfield area to be paved. They include all aprons, access ramps, fueling areas, stub parking areas, washracks, calibrating platforms, warm up pads, and 2,000 feet on each runway. From bidding on these areas asphalt is now excluded almost entirely. On the remaining areas, asphalt is permitted to bid but if it is only 5 percent lower or less than concrete, it still may not be used. This restriction even goes further, in that the 5 percent differential against asphalt will usually include large areas of concrete also required on the so-called critical areas. It therefore becomes not a 5-percent spread but in many cases a 25 percent differential which must be overcome. It is believed that these restrictions are neither in the interest of sound engineering to the degree in which they are now imposed, nor in respect to economy.

Mr. RIVERS. You say in that paragraph in substance that on future airfields the specifications which are now practically firm, that

these areas are part of the basic design and it constitutes roughly 25 percent of the aggregate construction?

Mr. GRAY. No, that isn't what I mean by the 25-percent differential. I mean that asphalt has to be 25 percent lower priced to be considered as an equivalent.

Mr. RIVERS. All these areas would make it more than 5 percent, wouldn't it, of the total?

Mr. GRAY. No, that refers to the difference in price, not the area.

Mr. RIVERS. What would it be in area? Certainly more than 5 percent. I think you said 10 percent.

Mr. GRAY. It might be 10 percent but that has no reference to the cost.

Mr. RIVERS. Let me ask you this:

These areas to which you have referred, you say the cost is such that it is not necessary to pave so much because the area is larger than is justified.

Mr. GRAY. That is right. The critical areas as set forth by the Air Force in our judgment are not critical to the degree they say they are.

Mr. RIVERS. Again there is too large a spread?

Mr. GRAY. Yes.

Mr. RIVERS. And the cost is greater and unnecessary?

Mr. GRAY. That is right.

Mr. FISHER. Mr. Gray, while on that subject: You estimated that 10 percent would be sufficient to take care of the so-called limited area?

Mr. GRAY. Yes.

Mr. FISHER. Now, you say the Air Force has elected to extend that beyond, I assume, the 10 percent that you refer to, to include the 2,000 feet at either end of the runways and certain other areas.

Now, do you know what percent that would represent with respect to the total?

Mr. GRAY. I think at times it might be 50 percent.

Mr. RIVERS. Mr. Chairman, may I ask this question:

Do you know, Mr. Gray, what the Air Force has in mind as coming off the drawing board is a bomber, which far exceeds anything we have now, in potentialities, capabilities, and hopefulness.

Now, that would be a Strategic Air Command base.

Do you know whether or not they have a plane that would require these guarantees to which we referred?

Mr. GRAY. No, I haven't any knowledge of these advance planes. I expect that is fairly secret.

Mr. RIVERS. Well, I don't know about that but I think it is possible they may have something that would do more than what we have now. I hope so. We have given them enough money to do it.

Mr. GRAY. I think we have to keep in mind this, it is the same thing that faces everybody that has anything to do with paving, any of the officials, that is, that the great portion of the facilities have already been built, and you have to use them, and you have to in some way provide for reconstruction and transition to these new heavier planes but in the meantime you have got to use what you have. You just can't come out with some new piece of equipment that makes obsolete the place on which it will run.

Conversely, I would say there is no engineering problem to provide a field that will hold up any load that I can foresee in the way of any plane of any size or any intensity of loading.

Mr. RIVERS. In answer to Mr Cunningham's question here, in response to what he brought out, in my State of South Carolina, we have abandoned concrete construction. We have better and more highways per capita than any State in the country.

We have found from our experimentation in our laboratories they have developed a highway construction of asphalt that is—that stands this intense heat. All of our highways, with the exception of bridges, are asphalt construction.

Mr. HESS. You may continue.

Mr. GRAY. To show how these changes have come about, a review of directives to the design and construction agencies—Corps of Engineers, and later Bureau of Yards and Docks—is made herewith. Prior to August 1952, competition between asphalt and concrete prevailed generally throughout the country. In particular locations one type or the other might be selected for local reasons, but usually the pavement with least cost was selected.

The first severe restriction on asphalt appeared in the directive of the Air Force dated August 19, 1952, to be applied to the fiscal year 1953 program. Pertinent excerpts follow:

(a) Selected areas on permanent Zone of Interior bases are designed for pavement with portland cement concrete as follows:

Hangar and dock access
Maintenance aprons
Fueling aprons
Parking aprons
Warmup pads
Stub parking
Wash racks
Calibration platforms
Runway ends (1,000 feet)

(*b*) The following areas on permanent Zone of Interior bases may be paved with either asphalt concrete or portland cement concrete on the basis of lowest first cost: Runways (except 1,000 feet on ends), taxiways, alert taxiways.

(*c*) All pavement areas on semipermanent Zone of Interior bases may be paved with either asphaltic concrete or portland cement concrete on the basis of lowest first cost.

This directive was immediately protested by the asphalt industry as being restrictive beyond any reasons discernible to its engineers but without avail. Moreover, while even under this directive, asphalt pavements continued to be built on both the remaining areas of permanent zone bases and more or less on all areas of the semipermanent zone bases, there were deviations and always in the direction of more portland cement, until now, under date of January 8, 1954, a new directive restricts use of asphalt still further. Both permanent and semipermanent zone bases appear now grouped together, and the areas on which asphalt may bid are so limited that the practical effect will be to eliminate competition almost entirely. Pertinent excerpts follow:

2. (*a*) *Critical areas.*—The following airfield pavement areas will be constructed of portland cement concrete:

(1) All apron areas including access ramps to hangars or docks.
(2) Stub parking.
(3) Washracks.
(4) Calibration platforms.
(5) Warmup pads
(6) Runway ends (1,000 feet).

(*b*) *Noncritical areas.*—All other areas subject to aircraft traffic, including but not restricted to runways (except end 1,000 feet) and taxiways, will be

constructed of either portland cement concrete or high-density asphaltic concrete, depending on the evaluation of various factors, such as quality of existing subgrade and the relative costs of the alternate types of surface. Decision as to type of material for noncritical areas will be made in accordance with procedures outlined in paragraph 3 below * * *

* * * * * * *

3. (*b*) If the spread in control estimate exceeds 15 percent, plans and specifications will be prepared only for the combination type involving both portland cement (critical areas) and asphaltic concrete (noncritical areas).

(*c*) If the spread in control estimate cost is 15 percent or less, plans and specifications and bidding schedule will be prepared for—

(1) All portland cement concrete; and

(2) A combination of portland cement concrete and asphaltic concrete, in accordance with paragraph (2).

Bids will be invited for both schedules. If evaluation of bids reveals a spread in costs of 5 percent or less between the competitive pavements, award of contract will be made * * * to the lowest responsive bidder for all portland cement concrete. If evaluation of the bids for the pavement reveals a spread in costs in excess of 5 percent between the competitive pavements, award will be made * * * to the lowest responsive bidder.

It will be seen from this last directive that not only is asphalt excluded from a large part of the airfield entirely, but that even to be considered on the remainder it is not on an equal competitive basis but must carry the handicap imposed by combination with the more expensive portland cement. It would seem that if materials are suitable for a given purpose and permitted as alternates, they should receive equal consideration. Either a material is adequate or it is not. If it is not, then it shouldn't be employed. If it is, why differentials of 15 percent and 5 percent to be overcome?

Points at issue: The points at issue therefore are twofold. One has to do with exclusion of asphalt from large areas where it is entirely suitable, as shown by the record, yet which are termed "critical" against its use. The other is the differential set up against asphalt even on the noncritical areas. It is contended by the asphalt industry that establishment of more complete competition between types should be had, to the end that the best and most economical pavement will be secured from the expenditure of Government funds. No one associated with the asphalt industry has any intention of wishing its product used unless it is completely suitable for the purpose. It is felt, however, that on the basis of experience, there is no reason for other than equality in competitive bidding between the two types (asphalt and concrete) at the present time, except for possibly on very, very limited critical areas and which would never be as much as 10 percent of areas to be placed under contract. The objective is to have a pavement which will serve the military needs in all respects. That is the No. 1 consideration. To establish a differential, therefore, and say that if one type is within 5 percent of the competing type, the award will be made to the low bidder but if it is more than that difference, it will be awarded to but one product—concrete—appears to fail to take into account this basic consideration of adequacy.

Frankly, the engineering reasons for any differential are not apparent to the asphalt industry. To limit practically all airfield paving to one type of construction cannot fail to produce a higher cost. It is believed that it will be evident on reviewing the record, that where asphalt and concrete are in competition—see exhibit A—the price of concrete, even where selected, is lower than where bids are confined to concrete only. It is but natural that this should be the case as there

is not the spur of necessity to cut costs to the minimum except when a competitor is to be considered.

In this day and age where taxation has reached practically the breaking point, and where there is so much need for public funds in many other directions, it would seem that every opportunity should be taken to save money by having competition to the fullest possible extent and thereby obtain the needed facilities at the minimum total cost.

Perhaps, when there is so much talking in billions, the thousands saved here and there may not seem important. Nevertheless, if considerable savings are to be made, they can only come about by the accumulation of many small savings. These are potentially substantial in airfield construction as on each individual field the savings may range from several hundred thousand to several million.

A careful study of exhibit A will indicate just how much these savings can be wherever full competition is provided.

Mr. NELSON. Mr. Gray, the effect of your testimony is this, is it not—the Air Force is in effect paying the cement industry a 5-percent subsidy so they can achieve a virtual monopoly?

Mr. GRAY. Well, I am not making any such allegation.

Mr. RIVERS. But you are not denying it?

Mr. GRAY. I say I don't understand it.

Mr. NELSON. Don't you think if the present policy is continued that the cement industry will have a monopoly on the construction?

Mr. GRAY. They will.

Mr. NELSON. If they do get such a monopoly is there anything to prevent their raising the cost again and again and again?

Mr. GRAY. I don't think so. I think where asphalt has been eliminated the price of the concrete has gone up.

Mr. NELSON. There is no other competitor to the concrete industry other than the asphalt?

Mr. GRAY. No.

Mr. RIVERS. Will you yield?

Mr. NELSON. Yes.

Mr. RIVERS. Supplementing my colleague's question: You also state that you are not given opportunity by these continuing and increasing directives to prove that you have a product that can do equally as well as these other products at a lower cost?

Mr. GRAY. That is right.

Mr. FISHER. Mr. Gray, do you have in mind any particular examples of where the cost on bids for concrete paving has been higher because there was no competition from asphalt?

Mr. GRAY. I think we have some set forth in this exhibit here, but there have been a number of places where they are not immediately adjacent where they call for bids on concrete only, and the bid price, we will say will be on the order of $7 or $8 a yard, but not far away where they had them in competition the price for concrete would drop to $6 or $7.50.

It can easily make a dollar a square yard difference.

Mr. RIVERS. You won't deny in certain foreign countries it may be cheaper to employ concrete?

Mr. GRAY. Yes.

Mr. RIVERS. Because the labor is plentiful?

Mr. GRAY. Yes.

Mr. RIVERS. Facilities are there?

Mr. GRAY. Yes.

Mr. RIVERS. Cost of transportation of asphalt?

Mr. GRAY. Yes.

Mr. RIVERS. You don't deny it may be more advantageous?

Mr. GRAY. No. My point is that engineering authority knows how to design both types today—both types of pavement to meet conditions and that those comparable designs placed in competition whichever one can be done for the least money, go ahead and do it. I think that is the point at issue.

Mr. RIVERS. You just want to be given opportunity to demonstrate?

Mr. GRAY. Yes.

Mr. HESS. With the exception of some critical areas where it might be necessary to put in concrete.

Mr. GRAY. Yes. And frankly I am very confident that once we just bring to bear the resources which we have in our laboratories, and in working with other people, we will shortly come up with a device for treating even these critical areas. The petroleum industry has done that in handling its hose and everything else.

Mr. HESS. Are you working on that now?

Mr. GRAY. Yes. But so far we haven't seen enough damage that justifies going to too large an extent; of doing special types of construction. I think there will probably be other testimony before the committee of people who have special products and I understand the record is very good on it. But so far we haven't been concerned enough with the damage that we have seen to think it was necessary.

In fact if this present directive hadn't come out we wouldn't have even protested more than we usually do to the Air Force. Because we are willing to go ahead as we do everywhere in working with the authorities that have the design to try to work with them to work out satisfactory ones. But when they just absolutely shut the door, so that you can't bid, why, we have felt we had to make some kind of a statement.

Mr. RIVERS. That is a new development, that directive.

Mr. GRAY. Yes.

Mr. RIVERS. Have you found those advances fluctuate with the advent of different demanding generals of the various commands responsible for these orders? That is possible you know.

Mr. GRAY. Our experience is that Air Force generals just don't like asphalt, period.

Mr. HESS. Is that only true of the Air Force?

Mr. GRAY. Well, those are the only people we complain about.

Mr. HESS. Do you deal with the Navy or Army?

Mr. GRAY. Yes, we get along very well with the Navy.

Mr. RIVERS. Of course the Navy does not have any continental bombers coming off the drawing board. You got to give them some credit about having some honesty about this. We represent all of them. That is why I asked if these intercontinental SAC bases might have something to do with that?

Mr. GRAY. I can state we know how to design pavements to take any conceivable load that you can bring to bear upon them.

Mr. RIVERS. And the heat, too?

Mr. GRAY. Yes.

Mr. HESS. Go ahead, Mr. Gray.

Mr. GRAY. In summary then the statement for the asphalt industry is as follows:

First. Asphalt and concrete are the two principal pavements in use today. There are a variety of types of asphalt pavement ranging from what is termed the low-cost type up to the heavy-duty type, the latter being the one recommended by the asphalt industry for heavy-duty airfields. This is a dense graded, hot-mix, hot laid asphalt placed under specifications suitably prepared by competent government agencies and laid under competent inspection. It is fully recognized that both types of pavement can be designed and constructed to carry any type of loading that is in existence today or expected in the future.

Second. It is fully recognized that there is a continuing change in the requirements for airfield pavements. The entire development from very light planes to those of present tremendous size and weight has taken place in a short time. Inescapably there are a number of the older fields which are now inadequate for the volume and kind of traffic which they must carry today. Accordingly it is but natural that these fields should require reconstruction and it is a matter of record that the most practical reconstruction, to obtain increased strength, is by resurfacing with hot asphalt and which has been done on a very large scale. While not in sympathy with some of the designs which have been used, believing that a 1½-inch thickness is not sufficient to resist the forces of traffic under present conditions, the asphalt industry appreciates that availability of funds made such procedure a necessary temporary expedient. However, where the resurfacing has been done with thicknesses from 3 inches and more with hot asphalt, excellent result have been secured and many thousands of square yards of concrete have been so resurfaced and salvaged and made useful as well as similar areas of asphalt pavements.

Third. Asphalt pavements have many advantages for airfield construction which are inherent because of certain properties not possessed by others. No pavement is perfect, consequently nominal maintenance is to be expected regardless of what type is used. It is contended, however, that this can be done easier and quicker with asphalt than with any other type. Much less weight of asphalt binder is required to construct an asphalt pavement than one of portland cement of comparable load support.

Fourth. The newer problems presented by jet planes as compared with older types, are in respect to fuel spillage, and the effects of blast. Damage is limited to very small areas, and of nominal amount under proper housekeeping.

Fifth. The directives of the Air Force, restricting the use of asphalt, and setting up so-called "critical areas" which are far larger than necessary, appears unwarranted. Moreover even on noncritical areas the competition is so weighted by preferential differentials in favor of concrete that it becomes increasingly difficult for asphalt to show its full economy.

Sixth. The potential savings to be had, where asphalt is permitted an equal competitive status are large indeed, as amply demonstrated in the record. Either it is suitable or it is not. If not, then it shouldn't

be used at all. But as it has thoroughly demonstrated its utility on millions of square yards of pavement, it certainly should receive equal consideration.

This chart happens to be the Plattsburg Airbase. Plattsburg. N. Y.

Mr. HESS. That is under construction?

Mr. GRAY. Yes. As originally established it was set up for asphalt and concrete. Then the directive came along and it is changed to concrete.

Now there is a very large area to be paved. You can see from the thickness of the two designs that they are very substantial.

The cost per square yard of the asphalt on the weighted average for the different areas is $3.73. Against the cost of concrete of $6.07.

There is a potential saving of over $2 million in that one field.

Mr. COURTNEY. Those were competitive bids where they?

Mr. GRAY. Yes. Those figures are based on competitive bids. But certain areas, why, they aren't going to use asphalt anyway, no matter what the price is.

Mr. COURTNEY. $3.73 represents the combined bid for asphalt and concrete in certain places?

Mr. GRAY. That is right.

Mr. COURTNEY. Does the $3.73 represent a combination.

Mr. GRAY. No, that is the cost of that asphalt pavement.

Mr. COURTNEY. Asphalt only?

Mr. GRAY. That is right. That is what I meant by this weighted average. To know what a pavement really costs you have to know how much it costs per square yard and multiply by the total square yards. If you add in dogs and cats and then divide them up, why, you don't get any kind of a true average.

Mr. HESS. I don't know whether I understand. The $3.73 per square yard is for asphalt for the entire airfield?

Mr. GRAY. No.

Mr. COURTNEY. For that part specified in the invitation for asphalt alone. Is that right?

Mr. GRAY. Yes. The bids were received for the area that was specified for asphalt alone.

Mr. HESS. Are there some areas specified for concrete alone?

Mr. GRAY. Yes. And they range $6.38, $6.62.

Mr. HESS. Those are the areas deemed critical by the Air Force?

Mr. GRAY. Yes. We think they are much larger than they need to be.

Mr. HESS. The other areas are areas that the Air Force feels can be built safely with either concrete or asphalt?

Mr. GRAY. Yes.

Mr. HESS. There is a difference between $3.73 and $6.07 on those areas?

Mr. GRAY. Yes.

Mr. NELSON. These are the areas which the Air Force feels can be built safely with either asphalt or concrete.

Mr. GRAY. Yes.

Mr. NELSON. If the price of asphalt is over 5 percent less than the price of concrete?

Mr. GRAY. Yes. But what they did was to throw it all out so it is all concrete. There is no asphalt at all on this base now.

Mr. NELSON. You mean they renegotiated to the low bidder?

Mr. GRAY. I don't know how they did it.

Mr. WELLBORN. No. They just let the contract last week.

Mr. FISHER. Was that done after the bids were first taken, the alternate bid, concrete and asphalt, and then they decided to eliminate asphalt completely, or at what point did they make that decision?

Mr. WELLBORN. The way they determined the bid quantities that come under this criteria of 5 percent. There is a lot of waste of figuring the 5 percent. This 5 percent is included here and includes the amount of apron areas and taxiway ends, concrete runway ends, other critical areas, so-called, which was included in the asphalt bid. When you get through figuring your full percentage you are not figuring comparable items such as asphalt pavement and concrete pavement of equal load-carrying characteristics but all other items into the 5 percent. Therefore this came into the criteria so they threw out all the asphalt and the whole job was let concrete.

Mr. COURTNEY. Well, is the 5 percent that you are talking about then, 5 percent of the surface?

Mr. GRAY. No.

Mr. COURTNEY. What is it?

Mr. GRAY. It means this. It means that if asphalt bids $1, and concrete bids $1.05, concrete gets the business. Even though they presumably are set up to be equal. Concrete starts off with that advantage in its favor. They will pay $1.05 for it even though the asphalt bid is $1.

Mr. COURTNEY. There is considerably more than 5 percent differential on this field.

Mr. GRAY. Yes. But including all these other items that are concrete, in other words, there is not only the amount of asphalt—take a runway, for example: they will take a runway add the cost of the asphalt and the concrete and come to a price. If that is not over 5 percent more than the cost of all concrete, then they make it all concrete.

In other words, won't even save the 5 percent.

Mr. RIVERS. By the testimony, they have never even approximated that. You have always had a differential of at least 5 percent.

Mr. COURTNEY. Yes.

Mr. RIVERS. You never have been that close.

Mr. COURTNEY. I still don't understand Mr. Gray—I hope I am not the only one—I still don't understand how this differential of 5 percent is applied.

Mr. WELLBORN. May I answer that? Let's take this instance here.

We have a total area to be paved of 929,043 square yards. Assuming areas in that which are considered critical might amount to 400,000 square yards of that area. In other words, the other 428,043 square yards would be the amount of which the Air Force considers asphalt can be used on properly. But the bid item is the total area. The flexible pavement design asphalt includes the 400,000 square yards of concrete. Which the Air Force will not let asphalt bids on.

Therefore, you have a total bid of 900, against 928,043 square yards, that will include, say, 400,000 square yards of concrete at $6.07, and 428,043 square yards of asphalt at $3.73.

You add those together against the total area at $6.07, and that is what the percentage is figured on. You are not figuring the two

pavement items at all. You are figuring the total items. The flexible pavement includes the concrete.

Mr. RIVERS. I still don't understand.

Mr. NELSON. Is it possible under that system of bidding for a bidder who is bidding concrete for the yardage you specified to put up his bidding asphalt—for the part you specified— to put up his bid so far as the concrete items are concerned?

Mr. WELLBORN. Yes.

Mr. NELSON. Is that possible?

Mr. WELLBORN. Yes.

Mr. NELSON. So that by putting his items for concrete up, the resulting difference because of the higher bid he puts in on concrete is less than 5 percent.

Mr. WELLBORN. Yes.

Mr. RIVERS. I don't understand Mr. Chairman—you still have a certain area of square feet to be paved with asphalt as an alternative. You can take 10 feet. I am not talking about the other critical areas. There isn't any way concrete can put in as low a bid as you can with the differential of 5 percent.

Mr. WELLBORN. That is right. But if you include all the concrete that they require, if you include that in the price of asphalt, then we are not in the 5 percent.

Mr. RIVERS. It still costs $6.73 cents?

Mr. WELLBORN. They don't separate it that way. Not according to the square yards.

Mr. NELSON. Would you yield?

Mr. RIVERS. Yes.

Mr. NELSON. The particular contractor that bids on the asphalt at $3.73 also has to bid on the concrete and he puts his price for concrete up over the $6.07, so that the resulting total of the whole bid is within the 5 percent range.

Mr. COURTNEY. Then this isn't a representative bid.

Mr. NELSON. That is the low bid.

Mr. RIVERS. Do you make one contract to do the whole busines?

Mr. WELLBORN. No, they can sublet. But this represents the area to be paved on it.

Plattsburg Air Force Base. The asphalt pavement was bid at $3.07 and the concrete at $6.07. If all the area would have been paved with asphalt it would have resulted in savings of over $2 million. But there were so many areas in this particular field that concrete was required on, which went into the lump sum bid of the asphalt bid, it did not effectively come within the 5 percent which is required in this criteria.

Therefore it all went concrete.

Mr. GRAY. To put it another way, there were 250,00 square yards on which asphalt was permitted to bid out of 928,000 square yards.

Mr. HESS. About one fourth?

Mr. GRAY. Yes. On which they were permited to bid at all.

Mr. RIVERS. Was that the access highways leading to it?

Mr. GRAY. No. That is the field.

Mr. NELSON. Mr. Gray, do you know of any other bases where a similar incident has occurred where asphalt has been the low bidder and they have negotiated for all concrete?

Mr. GRAY. Yes.

Mr. NELSON. Would you give the committee a list of them?

Mr. WELLBORN. Yes. I would like to recite one case. If you will notice in the exhibit A the first page here——

Mr. COURTNEY. Are you referring to page 6 of exhibit A?

Mr. WELLBORN. No. It is the first page of exhibit A. Recently, I as chief engineer of the Asphalt Interests Institute was called by one of our member companies in Texas who had contracted with a contractor to furnish asphalt on the Tye Air Force Base at Abilene, Tex. This contract had been let to the low bidder, which was asphalt. The contractor had begun work on the job. He was told that, to cease work and they would give him a negotiated price for all concrete. The contractor being a principally asphalt contractor, although he does lay concrete too, was quite disturbed and they got in touch with me.

I came to Washington to find out what the story was. When they tried to renegotiate this job for all concrete they found there was such a difference that they would leave it asphalt. That is the way that is set up. We show a total savings of $619,674. That is one case.

There have been other jobs which have been renegotiated after the contractor has started on the asphalt.

Mr. HESS. After a contract has been let to the lowest bidder?

Mr. WELLBORN. Yes, sir.

Mr. HESS. To build it with asphalt, then they renegotiate and bid with concrete at a higher price?

Mr. WELLBORN. Yes, sir.

Mr. HESS. Give us an example.

Mr. WELLBORN. Forbes Air base at Topeka, Kans., was let for asphalt at total cost asphalt of $2,765,079. The contractor had started to work. His work was stopped and it was renegotiated for concrete at $3,238,000, which is $471,000 more than it was.

Mr. RIVERS. Where is this?

Mr. WELLBORN. Page 2 of exhibit A. This man had moved in his asphalt plant, set it up, moved in aggregates, gotten the asphalt ordered and on the ground, and they stopped him and renegotiated for concrete.

Mr. HESS. When bids were asked for, were their alternate bids asked for?

Mr. WELLBORN. No, this was all asphalt.

Mr. HESS. All asphalt?

Mr. WELLBORN. Yes. The Government asked for bids of asphalt construction on this base.

Yes, the information we have is; this was let for all asphalt at this quantity you see—the bottom of the page—$2,765,000.

Mr. HESS. Do you have the date on that?

Mr. WELLBORN. No, I don't. It was sometime last year in 1953.

Mr. RIVERS. Is that a SAC base?

Mr. WELLBORN. I have no information on that. I doubt it. Being at Topeka.

Mr. COURTNEY. Do you know whether there were any termination costs because of the difference in the price of paving?

Mr. WELLBORN. I don't have that information.

Mr. COURTNEY. The $470,000 wouldn't necessarily reflect the whole cost to the Government of the change?

Mr. WELLBORN. No. It would not.

Let me recite one other case——

Mr. RIVERS. What happened to that contract?

Mr. WELLBORN. It is being built with concrete now at a renegotiated price.

Mr. RIVERS. So he moved out?

Mr. WELLBORN. Yes.

Mr. RIVERS. He might be laying concrete. They are looking for the money. This contractor could be in either business. They pay him damages and all that.

Mr. WELLBORN. I suppose.

Mr. RIVERS. Was there a clause for liquidating damages?

Mr. WELLBORN. I don't have that information.

Mr. RIVERS. We want to know what it is costing the taxpayer, too.

Mr. WELLBORN. That is the only information and is complete as we could get it. Sometimes information is a little difficult to get from the letting agencies.

Mr. HESS. Was the design changed in any way? Was it to be a different type of base so that the construction had to carry a heavier load?

Mr. WELLBORN. No.

Mr. HESS. It was not changed?

Mr. WELLBORN. It was not. This was done as a result of the criteria that came out. The Air Force came out with these various criteria directors. Soon as it came out they stopped the job and renegotiated for all concrete.

Mr. RIVERS. I know in my town they changed the design three times before it was built.

Mr. WELLBORN. That is a very expensive thing to do.

Mr. NELSON. Could I ask Mr. Chairman: if the Asphalt Institute will furnish us with a list of all the air bases where this or similar things have happened?

Mr. HESS. Can you do that?

Mr. WELLBORN. All the information we have is included in this brochure.

Mr. FISHER. Mr. Chairman, I am wondering if we can have the two exhibits included in the record, referring to Plattsburg and Tye Air Force Base?

Mr. GRAY. We can have them put into photostat for small size and put in.

Mr. FISHER. I think that would help to understand the subject.

Mr. GRAY. We will do that.

Mr. NELSON. Could the committee instruct counsel to furnish the Air Force with this list of bases and tell them that they will be required to produce all the facts?

Mr. HESS. We are certainly going to, Mr. Nelson.

Mr. HÉBERT. Mr. Gray, let's return to the third item in the summary, in which you say it is contended however, that this can be done easier and quicker with asphalt than with any other type.

Now, let's carry that to a conclusion to be sure of what we are talking about.

In asphalt as compared to cement, it would be admitted it would be a quicker and more flexible type of operation to maintain, but

would it be less frequent or more frequent than maintaining the cement? You may have to do this job which you can do quicker and easier 12 times whereas in concrete it would be only one time.

Mr. GRAY. That would vary with different situations. If you had to do something that you had to maintain it four or five times it wouldn't be the economical thing to put it in in the first place.

Mr. HÉBERT. Yes.

In other words, you don't complete your statement here. To be understandable, it should be stated that the flexibility of asphalt makes it quicker and easier to handle, but how many times do you have to do it.

In other words, does the maintenance cover a field of repeated adjustments?

Mr. GRAY. High type hot mixed will last years and years and years. They last longer than the period of service we have had on any of these airfields.

Mr. HÉBERT. The correct assumption from the records you have at hand and from your experience and knowledge is that numerically speaking the maintenance is equal in asphalt as in concrete.

Mr. GRAY. Yes. That is right. That is demonstrated on highways on such an extensive scale now there isn't any question about it.

Mr. HÉBERT. Your records reflect that.

Mr. GRAY. Yes.

Mr. HÉBERT. I wanted to get your statement complete here.

Mr. GRAY. Yes. The point that we emphasize in talking of this phase is that you can cut out if you have to, an area with asphalt and put in the repair and roll it and you are immediately using it, as against the curing time that is necessary elsewhere.

The second thing is that the ability to feather—I came down by air, I looked at two concrete aprons that had been reconstructed with asphalt overlays and some are still good enough to continue to use.

So instead of covering them all they featheredge from the asphalt overlay to the concrete. It is perfectly usable.

That, we think, is quite an advantage, because it means if any area does show it can be given another lift and the whole thing is immediately usable.

Mr. FISHER. Mr. Gray, with regard to the length of the life of these various types of concrete and asphalt, suppose two pavements, one concrete and one asphalt, are constructed properly and then the two should be abandoned as we did many fields after the war for 5 years and are not touched during that period, and then are reactivated. What will be the relative deterioration, degree of deterioration of the two, could you say anything about that? Which would survive the better over a period of 5 years, say, without any upkeep?

Mr. GRAY. I doubt if there would be any difference between the two. If you put in enough binder in each one, they should, if built right, so that they resist the atmospheric forces, if they went for a long time I think they would both tend to disintegrate. Atmospheric forces in some respects are more damaging to pavement than the traffic they have to carry.

Mr. RIVERS. Of course, you have got to have a binder on concrete because if the water seeps in it will blow it up.

Mr. GRAY. That is right.

Mr. RIVERS. And the weight is suspend to the base, anyway.

Mr. GRAY. Yes.

I think we have had that happen on both types of field. We did have a period where they weren't used and then they were reactivated and water had gotten in both of them, the asphalt fields were brought back rather quickly by simply resurfacing and fixing the drainage up, and the good deal of concrete was brought back, too, by resurfacing. There have been tremendous areas of concrete that have been resurfaced with asphalt.

Aprons and runways, and so forth.

Mr. HESS. Mr. Wellborn, you cited two specific cases here, one the Air Force base in Abilene, Tex., the other at Topeka, Kans. Are those the only two you have?

Mr. WELLBORN. No—all of the exhibit A is the same. The Plattsburg base and the Tye Air Force Base are described in detail in exhibit A. Actually, this charter is reproduced not as a chart but as figures in this exhibit A.

Mr. HESS. I am asking whether there are any other cases outside of the Topeka, Kans., case and the Abilene, Tex., case, where they have asked for bids for asphalt and then renegotiated and decided they are going to construct with concrete.

Are all of these cases cited here the same?

Mr. WELLBORN. No; the remarks will tell you what they are. Those are the only two cases we have of record where they renegotiated.

Mr. FISHER. It should be pointed out, however, that in the Abilene case, they changed and finally let the contract to the asphalt.

Mr. WELLBORN. Yes. It had been let to asphalt originally. They stopped the job for renegotiation, and then changed their mind again.

Mr. FISHER. After protest was made. Somebody talked to me about it, I recall. After protest was made, they canceled out the renegotiation whereby they were letting the contract to concrete and stood by the original bids and it will be an asphalt contract.

Mr. HÉBERT. It would not have been unless protest was entered.

Mr. RIVERS. I notice the Hunter Base at Savannah, I happen to know about that. I see here the saving in asphalt was $3 million.

What is that doing? Did they keep it in asphalt?

Mr. GARDNER. That would have been the saving had all the areas been let at comparable bid prices.

Mr. RIVERS. What did they do? Did they do the same as they did at Plattsburg?

Mr. WELLBORN. That is what we understand. These are just items, bid items as they were taken. We have no information yet of how that base was let.

Mr. RIVERS. You were precluded from bidding because of this allegedly arbitrary order disqualifying you in the first instance because of the specifications.

Mr. WELLBORN. Yes, according to this criteria which restricted our bidding.

Mr. RIVERS. Is that what all of these exhibits comprise, areas where you were disadvantaged in bidding?

Mr. WELLBORN. Yes. More or less. It is explained in the remarks. We didn't add anything to the Tye Air Force Base there because it went to asphalt.

You can realize the savings in using asphalt. Under that you notice the McClellan Air Force Base and Edwards Air Force Base. There it got to the point almost of advertising, I was in California at the time, we had gotten certain asphalt contractors interested in this huge job there at Muroc, Calif., and we expected comparable bids to be put out.

The Corps of Engineers there was instructed from the Air Force that they would not submit the asphalt design but would only submit the total concrete design; which they did.

They got a remarkably low bid on the concrete. That will be the biggest runway in existence, I suppose. We were not allowed to bid on this.

At McClellan we were allowed to bid on an apron, we were $148,535 low, on a bid of $307,000. Yet, we didn't get the job. That is 35 percent. But they were directed that this would be concrete regardless of low bid.

Mr. RIVERS. Why did you bid to start with?

Mr. WELLBORN. Well, they are contractors.

Mr. FISHER. Did a new criteria come out that affected that situation?

Mr. WELLBORN. Evidently, it did at that time.

Mr. RIVERS. You say that is the longest runway on earth?

Mr. WELLBORN. No, the one at Muroc is. It is under construction now. All concrete.

Mr. COURTNEY. This bid you are talking about now is July 1952. That is before the latest criteria.

Mr. WELLBORN. Yes; but the criteria that came out in August 1952—this was when the bid was taken in July—in August 1952 the criteria came out that said all aprons would be concrete regardless.

Mr. RIVERS. You don't complain about that, do you?

Mr. WELLBORN. We hadn't complained about it. We hadn't complained about that.

Mr. COURTNEY. The specific question asked you by Mr. Nelson, so we will be clear, What is contained on exhibit A with the six pages some of which we have been referring to? Precisely what information is set forth there?

Mr. WELLBORN. Airports on which alternate bids were taken or bids were taken on comparable items or reliable estimates made on the same or comparable items that a savings could be calculated. These are the only jobs we could get together on information where we have had comparable items to figure bids from.

Mr. COURTNEY. They don't all represent actual bids.

Mr. WELLBORN. Yes, or actual items from the Corps of Engineers.

Mr. NELSON. Mr. Chairman, then it is true, is it not, that the Air Force discriminates against the asphalt industry first by sometimes issuing specifications for bid which are only for concrete and do not allow asphalt to bid; secondly, when they ask for alternate bids, there is less than a 5 percent differential and it goes to cement.

Mr. WELLBORN. Yes.

Mr. HESS. Are you gentlemen finished?

Mr. GRAY. Yes, sir.

Mr. HESS. Any other questions by the members?

Mr. CUNNINGHAM. I notice in driving over the country so often you see a sign, "slippery when wet."

Further observation tells me in most of those cases they have asphalt instead of concrete.

Mr. GRAY. Yes.

Mr. CUNNINGHAM. Could you say something about the relative differences between asphalt and concrete as to skidding?

Mr. GRAY. I doubt if there is any difference between the two terms properly built. Although this is another phase that has entered into competion. As you can well imagine with two industries of the size of asphalt and portland cement, there is a constant competition for all kinds of business wherever they are possible of being used.

On the various committees on which our engineers find themselves and working with different universities, studies are made on these matters, such as skidding.

Skidding is a characteristic that is reflected by the coefficient of the friction of surfaces. These studies that were made at the Iowa State College, at the experimental station, show in a set of curves here what makes of asphaltic concrete properly constructed have the highest coefficient of friction of any type of pavement.

Now, you can have pavements that would be improperly constructed or as we have in the hundreds of thousands of miles of asphalt pavements all the way from oil roads, surface treatments, road mixes, done by different kinds of government, sometimes there is too much in there, and you have a flushing to your surface.

Mr. CUNNINGHAM. What prompted the question was the fact that the signs I have noticed in driving in many States nearly always it is where it is asphalt instead of concrete.

Mr. GRAY. Well, you will find them in New York, for example, slippery when wet in many many situations. It reflects the condition of that particular surface. As a matter of fact, in New York State they have put surface treatments with asphalt on hills of pavements constructed of portland cement concrete to change them from being slippery to make them nonskid.

Mr. CUNNINGHAM. That is all.

Mr. HESS. Thank you very much, Mr. Gray. We appreciate very much your giving us this information.

Mr. GRAY. Thank you for your consideration.

Mr. HESS. The committee will adjourn until tomorrow morning at 10 o'clock, and at that time we will hear the concrete industry.

This concludes the presentation by the Asphalt Institute.

Mr. GRAY. Yes. This concludes our presentation.

(Whereupon, at 11:45 a. m., a recess was taken, the committee to reconvene at 10 a. m., of the following day, Thursday, February 4, 1954.)

(The following statements were furnished for later insertion.)

SUPPLEMENTARY STATEMENT BY THE ASPHALT INSTITUTE

Pursuant to the testimony presented by the Air Force, the Navy, and the Corps of Engineers, it is believed that the situation as portrayed in the statement for the asphalt industry by the Asphalt Institute on February 3d has been supported rather fully as follows:

1. The Air Force desires concrete and insists upon its use except where the cost advantage in favor of asphalt is so great that it cannot be ignored, notwithstanding recommendations of the construction agency. This hardly seems consistent, in view of testimony, even by the Air Force, that asphalt pavements are serving satisfactorily on such huge areas of so-called critical areas. In fact

testimony by General Ramey referred to some airfields (such as Thule) as being concrete when actually they are all asphalt.

2. That these areas designated as "critical" under Air Force directives are therefore far larger than required, in reality being less than 10 percent of the total area as contrasted with 60 percent to 75 percent of the total area insisted upon by the Air Force.

3. That damage from spillage has been greatly exaggerated, in fact many planes do not spill at all. That on many all-asphalt fields no damage whatsoever has been reported, and that on the much complained of Williams apron in Arizona damage, if any at all, was limited to a very small area due to inadequate construction procedures (see Corps of Engineers testimony.)

4. Similarly that damage from heat and blast likewise has been greatly exaggerated in the Air Force reports.

5. It can be concluded therefore that problems of spillage, heat and blast have been solved by new design and construction techniques except on very, very, limited areas (see Corps of Engineers testimony).

6. It is very evident that pavements of either asphalt or concrete can be designed to cary any load, and that those now in use of either type can be strengthened as required by resurfacing. For this work asphalt is particularly well suited.

7. Very few maintenance records on airfields are available, because the weight and type of planes has increased so rapidly that pavements designed for the lightest planes of World War II have required subsequent strengthening by resurfacing long before appreciable maintenance was ever needed. A typical situation is shown in exhibit D attached, where the original badly cracked and spalled concrete pavement was salvaged by resurfacing with asphalt (Lowry Air Force Base).

8. Both asphalt and concrete are readily maintained by well established maintenance procedures. Costs for heavy-duty pavements of equal load carrying capacity are similar, but the trend is favorable to asphalt. One of the most recent impartial highway studies (highway pavement maintenance costs being usually higher than on airfields) by the Oklahoma Turnpike Authority, gave conclusive evidence in this regard. Copy is attached as exhibit E.

9. The first cost of asphalt is generally 20 percent to 50 percent less than for portland cement concrete. In General Eaton's letter to the Armed Services Committee, dated July 6, 1953, he stated that the cost of concrete was approximately one and a half times the cost of asphalt. In many instances it may be only a third the cost of concrete. Thus while the potential savings in the entire program as indicated by General Washbourne were only some 15 million, this could come about only if asphalt either were excluded from bidding on large areas, or put to a disadvantage through establishing inequitable differentials. Actually, with proper competition, however, the potential savings on the present program would be on the order of $50,000,000.

10. This evidence is substantiated by the proposed paving at the Homestead Air Force Base in Florida where the indicated saving in favor of asphalt was so great that it could not be disregarded, being around $3 million on just this one field.

11. Just why asphalt aprons are good in Florida or in Thule, and not in Plattsburg, N. Y., however, is somewhat of a mystery, for the potential saving there, had there been suitable competition, was over $2 million. See exhibit F attached.

12. Relative to demonstration by United States Rubber and Flintkote, this is not representative of actual field conditions. The asphalt industry welcomes any development that will make its product more widely useful, but it does object to comparisons which are not pertinent. Just as a matter of curiosity, therefore, it would like to have noted that the asphalt sample used was rough sawed, whereas the tar sample was polished. In other words, the latter was dense finished as contrasted with the open texture of asphalt sample used, and which accounted in large part for coloring the fuel in which immersed.

13. It is important to emphasize the part played in use of asphalt after Pearl Harbor, when the country's desperate situation required immediate building of a large number of airfields with hastily assembled engineering and contractor organizations. Some of the surfaces were made scanty indeed in order to get operations underway, and it is a wonder that many served as well as they did. It is to be noted further that practically all of these fields built for the lighter weight propeller type aircraft have been capable of adaptation to satisfactory use under jet-type planes with heavier and more intense wheel loads and their

peculiar service conditions. Without the asphalt pavements then so quickly made available, we would have been in sorry condition indeed.

14. These current service conditions are not new to the asphalt industry. Fuel spillage, blast, and heat have been experienced in many other fields of use for years. Asphalt is placed on industrial floors to resist acid and alkali spillage, it is used to cover battery boxes, its long record on parking lots where dripping oil is far more serious than fuel spillage have all led to appropriate techniques to meet these conditions. The test tracks for tanks used in the last war were practically all asphalt—at General Motors, Chrysler, Ford—because asphalt was most resistant to tearing action of the treads under both extreme heat and cold. Asphalt pavements were laid at below freezing temperatures, Quonset, Iceland, and elsewhere when pavement construction with portland cement would have been impracticable.

15. Asphalt institute engineers have watched the development of jet planes and the effect on asphalt surfaces since the first plane came into use. They have examined field after field to appraise current damage as well as to estimate that likely in the future. A statement by one staff engineer, Mr. Frank H. Gardner, who has visited many fields is attached as exhibit G. They all have come to the conclusion that the current situation is at its worst, and that with use of more volatile fuels, improvement in planes, and better operations, any damage will be easily repaired, and at nominal cost for over 90 percent of all airfield paved areas. It may be that for use under after-burners and rocket-assist usage damage may be more substantial a condition against which neither concrete nor asphalt is completely resistant. Even here, however, the pavement which can be most easily and economically replaced is asphalt.

16. It is concluded then, that on the basis of the record of this hearing, that (a) asphalt has proven its adequacy for all areas of airfields, except possibly, very limited ones directly under the plane where fueling operations are carried on; (b) that the present directive of the Air Force dated January 8, 1954 is unnecessarily restrictive as to "critical" areas, and that the differentials established for "noncritical" areas in favor of concrete are entirely unwarranted; (c) that very large possible savings in cost of building new airfields and reconstructing older ones, will be lost if this directive is allowed to stand. On the present program this saving can easily be as much as $50 million.

EXHIBIT G

STATEMENT OF FRANK H. GARDNER, DISTRICT ENGINEER, THE ASPHALT INSTITUTE

My name is Frank H. Gardner. I am a registered professional engineer, District of Columbia, No. 476. I am a member of the American Society of Civil Engineers, the Association of Asphalt Paving Technologists, the Highway Research Board, and other engineering groups. Most of my profession career has been as a public servant wherein I regarded the expenditure of public funds as a trust to be discharged, without partiality or favor. I accepted by present job with the Asphalt Institute very recently with the assurance that I would never be called upon to take any position inconsistent with liberty to express my best engineering judgment.

From February 1951 to January 1954, immediately preceding my joining the Asphalt Institute, I served as Chief Paving Engineer for Headquarters, Military Air Transport Service, one of the major commands of the United States Air Forces. So for almost 3 years I have lived with the problems now before this committee.

During the approximately 3 years I served with the Air Forces I walked over and carefully inspected all the airfield pavements at the following airfields:

1. Grenier Air Force Base, Manchester, N. H.
2. Westover Air Force Base, Chicopee Falls, Mass.
3. McGuire Air Force Base, Fort Dix, N. J.
4. Dover Air Force Base, Dover, Del.
5. Charleston Air Force Base, Charleston, S. C.
6. West Palm Beach Air Force Base, Fla.
7. Orlando Air Force Base, Fla.
8. Boca Raton Airport, Boca Raton, Fla.
9. Mountain Home Air Force Base, Idaho.
10. Great Falls Air Force Base, Mont.
11. Travis Air Force Base, Fairfield, Calif.

12. Hickam Air Force Base, Honolulu, Hawaii.
13. Johnson Island.
14. Bellows Air Force Base, T. H.
15. Wheeler Air Force Base, T. H.
16. Barking Sands Air Force Base, T. H.
17. Kindley Air Force Base, Bermuda.
18. Keflavik Airport, Iceland.
19. Lajes Airport, Azores.
20. Santa Maria Airport, Azores.
21. Wheelus Air Force Base, Tripoli, North Africa.
22. Daharahn Airport, Saudi Arabia.
23. Andrews Air Force Base, Md.

I have made a somewhat less complete inspection of airfield pavements at Harmon Air Force Base, Newfoundland; Orley Airport, Paris, France; Weisbaden Airport, Germany; Reim Main Airport, Germany; Ciano Airport, Rome, Italy; the airport on the Isle of Cyprus; Cairo Airport, Egypt; the new airport at Casablanca, North Africa; McChord Air Force Base, Seattle, Wash.

I have investigated many reports of damage to pavements from fuel spillage, jet blast, and heat. Some of the areas inspected were subjected to the very heaviest jet plane usage. In all of these inspections I have found that the worst "damage" consisted of softening of the asphalt in maintenance areas where spillage was frequent and of long duration. The softening permitted the aircraft wheels to depress the asphalt from ¼ inch to ½ inch deep for an area the size of the tire imprint, about a foot wide by a foot and a half long. I have not been able to find softening from fuel spillage on runways, taxiways, and other areas, except small maintenance areas which are subjected to the constant spillage in a concentrated area. The spillage at other areas is so dispersed that spillage in one place has completely evaporated before that area is again, if ever, subjected to another spillage.

The worst "damage" I have ever found from blast and heat was at Keflavik after the largest jet aircraft operation, I was told, in history, when all the jets of NATO were there. All these planes took off from the same end of the same runway. There were a few smoked or scorched areas discernible where a plane had stood unusually long. These smoked areas were 2 to 3 feet wide and 5 to 10 feet long. There were possibly a dozen such places. I tried carefully to pry out aggregates to see if any had been loosened. I was unable to find any loosened aggregate and none was blasted out or displaced.

The new regulation of the Air Force providing for 2 inch thickness of asphalt pavement on the blast pads back of the ends of the runways, warmup pads and taxiway turns surely is not consistent with their allegation of damage from jet heat and blast, but it is evidence that an asphalt pavement is suitable for this purpose.

In all of my inspection of airfield pavements I have never found a spot which needed substantial repair as a result of damage from fuel spillage, jet blast or heat. Several of the most used airports in the world, such as Thule; Keflavik, Iceland; Lajes, Azores; Tripoli; Daharahn, Saudi Arabia; and Hickam in Honolulu are paved entirely with asphalt. Hickam has a small area of concrete apron but all of it has failed and work was begun within the past 2 or 3 months on a contract to remove all of the portland cement concrete and replace it all with asphaltic concrete.

The satisfactory performance of asphalt in all areas of these and many other airports raises serious question as to the justification for the expenditure of funds for any pavement more expensive than asphalt in any area of an airport.

It is my considered judgment that consideration of the use of any pavement more expensive than asphalt could be justified only in definite maintenance areas, such as hangar floors, the areas at nose docks immediately under the engines of the planes or in the case of jets extending back over the blast area (this area would be from a few feet to a maximum of 50 to 100 feet square at each site), and aircraft wash racks. My observation has been that neither the frequency nor the intensity of damaging causes in other so-called critical areas, such as runway ends, hardstands, and aprons, warrants the expenditure of funds for any pavement more expensive than good quality dense graded asphalt.

Such a policy would save many millions of dollars and be consistent with sound engineering and faithful discharge of the high responsibility of public servants in the expenditure of hard earned tax funds.

AIRSTRIP PAVING MATERIALS

THURSDAY, FEBRUARY 4, 1954

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON DEFENSE ACTIVITIES OF THE
COMMITTEE ON ARMED SERVICES,
Washington, D. C.

The subcommittee met, in room 304, Old House Office Building, at 10 a. m., the Honorable William E. Hess, chairman of the subcommittee, presiding.

Mr. HESS. Let's proceed.

Mr. COURTNEY. Mr. Chairman, Captain Kehart is here from the Bureau of Yards and Docks to give the Navy's viewpoint on this subject. He has a prepared statement.

This is Capt. M. W. Kehart, Assistant Chief of the Bureau of Operations, Bureau of Yards and Docks, of the Navy Department.

STATEMENT OF CAPT. M. W. KEHART, BUREAU OF YARDS AND DOCKS, NAVY

Captain KEHART. Gentlemen, my statement pertains to the policy relative to the use of rigid type pavements, portland cement concrete, and flexible type pavements, bituminous surfaced, in the design and construction of airfields for the Naval Establishment.

I might add that I have responsibility for the construction and engineering of Naval Shore Establishments under the Chief of the Bureau of Yards and Docks.

The rapid and significant changes in naval aircraft during the current transition from reciprocating-type engines to jet-type engines have necessitated a parallel substantial change in policies and procedures relative to the design and construction of airfield pavements to accommodate contemporary high-performance aircraft as well as the aircraft of the future. Among the more significant current problems which affect airfield pavement design and construction are heavier aircraft with greater wheel loads, extremely high pressure aircraft tires, the high temperature and velocity of the jet engine exhaust gases, higher aircraft takeoff and landing speeds, and significant changes in aircraft fueling procedures. The airfield pavement designer must give appropriate consideration to all of these factors, and at the same time be strongly guided by the necessity for economy during periods of continually rising construction costs and the resulting tremendous burden on the country and the taxpayer in financing the cost of modernizing our naval airfields.

With due consideration to all of these relevant factors, the Bureau of Yards and Docks of the Navy has, of necessity, taken a position of

leadership in this new field, with respect to the civilian engineering and construction industries, because of its long and varied experience with the design and construction of airfield pavements, and its better appreciation of the requirements of the Navy with respect to current and future aircraft. The Bureau has been a leader in sponsoring extensive research and testing programs in this field and has used the results of these programs to indoctrinate civilian consulting and design engineers and construction contractors who work with the Navy in the airfield program. Also, the leaders in the airfield pavement materials industries have worked closely and cooperatively with the Bureau in this matter.

A complete technical discussion of the many diversified and complex problems of engineering and economy involved in modern airfield pavement design and construction is beyond the scope of this statement. However, it is considered significant to summarize the current policies and procedures of the Navy which have been developed from our experience to date.

In general, the current policies and procedures of the Navy with respect to the use of flexible type pavements, rigid type pavements, or combinations of the two types, are as follows:

A. NEW AIRFIELD PAVEMENTS

(New pavements may include the construction of extensions of existing pavements as well as construction at locations where no pavements existed previously.)

This category does not include "overlay" pavements, which are placed over old pavements to increase the capacity or serviceability of the old pavement.

1. Rigid-type pavement (portland cement concrete): The Navy's policy is to construct the ends of all jet runways and parallel taxiways, warmup aprons, parking aprons, and fueling aprons of portland cement concrete. These are the areas of greatest abuse from modern aircraft usage and related operations and are therefore designed for maximum life to reduce maintenance costs and the possibility of immobilizing an airfield during the periods of extensive repairs, it being considered that this latter factor may well outweigh considerations of initial construction costs. Runway and taxiway ends and warmup aprons are constructed of portland cement concrete in order to provide greater resistance to the detrimental effects of jet aircraft exhaust gases at high temperatures and great velocities. Fueling aprons are constructed of portland cement concrete to provide greater resistance to the detrimental effects of spilled aviation fuel. Aircraft parking areas are constructed of portland cement concrete for longer life than bituminous surfaces, because the parking areas do not normally receive the well distributed kneading action produced by moving planes and without which a bituminous type pavement tends to lose plasticity, become oxidized, and gradually deteriorate. Reinforcement is used in the portland cement concrete pavements at the runway ends, warmup aprons and taxiway ends, but not in aircraft parking and fueling areas.

2. Flexible-type pavements (bituminous surfaced): The policy of the Navy is to use flexible-type pavements for airfield runways and taxiways, with the exception of the ends referred to above. It is

considered that the use of flexible-type pavements for these larger areas is more economical when all factors of economy of initial construction, maintenance, and the possibility of subsequent modernizations are properly weighed. An exception to this policy would be the case of an airfield where no jet aircraft operations are contemplated in which case the entire runway and taxiway complex would be constructed of flexible-type pavements. A second exception, but admittedly one of rare possibility, would be the case of an airfield site where no suitable aggregate for flexible-type pavement construction is locally available, but where such materials would need to be transported from a distant source. Under such circumstances, it might prove more economical in initial construction to build all airfield pavements of portland cement concrete since the required tonnage of imported materials would be less for the rigid type than for a flexible-type pavement, considering not only the aggregate requirements of the wearing course but also of the base.

B. REINFORCEMENT OF OLD AIRFIELD PAVEMENTS

At many Navy airfields, it has been necessary to strengthen old pavements, which were originally designed for light aircraft with low-pressure tires, and subsequently were planned for use by modern high-performance aircraft. In such cases, the Navy policy is to construct portland cement concrete overlays at the runway and taxiway ends when no extension is involved, and to use bituminous flexible-type overlays on all of the remainder of the runways and taxiways.

C. ECONOMICAL ASPECTS OF AIRFIELD PAVEMENT TYPES

1. The cost of initial construction of new pavements: The difference between the initial costs of portland cement concrete and bituminous surfaced pavementst, each having the same tire load rating, is extremely variable in this Bureau's experience, but generally, the bituminous-surfaced pavements tend to be less costly. The Navy's airfield construction program is worldwide, and widely diverse conditions with respect to subgrade soils, drainage and climate are encountered. Under these circumstances, and average difference in cost per square yard for different types of pavement tends to be meaningless. In one locality the natural ground may be highly stable, granular material of a nature such that no base and/or subbase course is required, and aside from grading, drainage, etc., paving requires only a substantial bituminous surfacing for the flexible-type pavement, at a cost that is less than a third of that of a concrete pavement. On the other hand the airfield may be many miles from any good source of suitable borrow materials and the natural ground may be soft, with a high-water table. In this case, the cost per square yard of concrete may be less than that of a bituminous-surfaced pavement. Both extreme cases have been encountered in Navy experience.

2. The cost of overlay pavement construction: A bituminous surfaced flexible pavement is more adaptable to stage construction than one of portland cement concrete. An overlay of concrete on concrete or of concrete of flexible pavement must, of necessity, have a minimum thickness of about 6 inches to be structurally adequate. However, an overlay of either bituminous concrete alone, or of flexible-

type pavement topped with bituminous concrete, may have any thickness in excess of an inch. Thus the adaptability of flexible type bituminous-surfaced pavement overlays on old pavements tends to render the initial cost less than that of concrete overlays. This has usually been the tendency in Navy experience.

Usually old pavements tend to have irregular surfaces. These are localized depressions, generally, and a leveling course (usually of bituminous stabilized sand or other aggregate) is required for restoring grades before the pavement overlay can be constructed in any case, whether the overlay selected is concrete or of the flexible type. Normally, it tends to minimize initial cost to use the same type of material for leveling as for strengthening the old pavement.

3. Maintenance costs: Although the anticipated cost of maintenance during the life of an airfield pavement, as in the case of any other structure, is a very significant factor in original design and construction decisions, very little valid and relevant information in this regard is available. This condition exists for the following reasons:

(*a*) The type and volume of usage of a naval airfield has seldom been constant for a long enough period to draw valid conclusions.

(*b*) Periodic rebuilding or strengthening of existing pavements in order to accommodate aircraft of characteristics different than the aircraft for which the pavement was originally designed, destroy all continuity in maintenance cost research.

(*c*) The limited maintenance cost records which do exist and cover an appropriate length of time to be of value are applicable to pavement types which are now obsolete. On the other hand, the modern type airfield pavements which have been built in the last 3 years have not yet received sufficient usage to generate any maintenance cost experience of value.

Giving due consideration to these very limited influences, the Navy's general experience has been that rigid-type pavements tend to be somewhat less costly to maintain than flexible-type pavements particularly when long periods of inactivity are involved.

Gentlemen, that is the end of my statement.

Mr. HESS. Are there any questions?

Mr. NELSON. Yes, I have some questions.

Mr. HESS. Mr. Nelson.

Mr. NELSON. Captain, in paragraph 3 of your prepared statement you indicate to the committee that you haven't had experience enough to make any valid conclusion as to maintenance costs.

Captain KEHART. Yes.

Mr. NELSON. In the last paragraph you say that the maintenance cost for rigid pavements are less than flexible. Is that just a guess by the Navy?

Captain KEHART. I would like to modify that last paragraph to the extent that when a pavement is inactive, for a long period of time, and to reactivate that particular field, you might have to resurrect the complete top surface if it is flexible type, whereas if it is concrete pavement, and also inactive you will only have to reactivate the joints. That is really what I mean by that statement.

Mr. NELSON. How much experience has the Navy had to estimate the life as between rigid-type pavements and flexible?

Captain KEHART. I don't think we have enough concrete data, to make any comparison.

Mr. NELSON. So you cannot give us any conclusion as to the life of rigid pavement as contrasted with flexible pavement?

Captain KEHART. No, sir. We can only make a statement and the last paragraph is a statement that applies to those that are inactive.

Mr. NELSON. That is the Navy's estimate?

Captain KEHART. That is correct.

Mr. NELSON. Now, in the second page of your statement, you make this statement: you indicate that if the aprons and the taxiways were made of flexible pavement instead of rigid pavement, the possibility of immobilizing an airfield during the period of extensive repairs—Why is that so? Why is an airfield immobilized any more when you repair flexible pavement than when you repair rigid?

Captain KEHART. The statement there is meant to infer that the number of times that you would have to go into a repair, is less likely if you have a concrete pavement, than if you have a flexible pavement. Because a flexible-type pavement receives continuous damage from our jet aircraft.

Mr. NELSON. Yet you stated in your last paragraph that you hadn't had experience enough to know as to the cost of maintenance as between flexible and rigid pavements.

Captain KEHART. Well, I changed my last statement. My last paragraph of my statement. I modified that to say I am talking about inactive pavement.

Mr. NELSON. Then the statement you make in A–1 would only apply to airfield that would be reactivated after a long period of inactivity. Statement in A–1 on page 2 of your statement.

Captain KEHART. No, I don't. I am talking about those active and have either the ends in concrete or asphalt. I maintain that if it is concrete then you have less number of times that you will have to rebuild that pavement or will have to repair it because concrete will stand the blasts and the velocities and heat much better than the asphalt pavement.

Mr. NELSON. I don't want to confuse anyone, Captain, but you have me confused because you have said you haven't had adequate experience as to the life as between rigid pavement and flexible pavements and you say in the last paragraph of your statement that you don't have an adequate figure to compute maintenance cost. Yet you make a definite statement that you have these particular areas of concrete, of airfields, because you think they have a longer life.

Captain KEHART. In the last paragraph, I said tend to be somewhat less costly. I don't think I have made a statement that I have positive proof.

Mr. NELSON. No. I say you haven't.

Captain KEHART. We really don't have enough experience.

Mr. NELSON. That is the point I make. You said you haven't had enough experience. Yet you make a statement that these are the areas of the greatest abuse in modern aircraft usage and related operations and therefore designed for maximum life to reduce maintenance cost and the possibility of immobilizing an airfield during periods of extensive repairs. Why is an airfield immobilized if these areas are made of flexible pavement and not if it is made of rigid pavement?

Captain KEHART. Repeat that please.

Mr. NELSON. Why are these areas immobilized if you have flexible pavement and are not immobilized if you have rigid pavement when you are making extensive repairs. That I don't get.

Captain KEHART. Yes, we have had experience, particularly in flexible-type pavement. We have had to immobilize the areas of the ends when they are flexible concrete for extensive periods of time. We have had to immobilize them for an extensive period of time because they are made of flexible concrete and they have been you might say injured or made immobile or made unusable because of the hot-air blasts from the jets. We have had extensive experience along that line; yes, sir.

Mr. HESS. Could you tell us some of the fields you have had that experience?

Captain KEHART. Yes. I would say in practically all of our major fields where we are using jets extensively and where we have had the ends in flexible pavement. We have records sir that can be introduced into the hearing.

Mr. HESS. You have replaced the asphalt with concrete?

Captain KEHART. Yes, we have in most cases. Today our practice is in all airfields where jets are used to make the ends out of concrete or to replace the existing asphalt that has been damaged, with concrete.

Mr. HESS. The reason you did that was because in the experience you have had, the blasts of the jet does damage the pavement?

Captain KEHART. Yes. That is correct.

Mr. HESS. Any other questions?

Mr. BATES. Two years ago at Pearl Harbor we had the discussion of asphalt versus concrete, concrete versus bituminous, and we didn't get very far.

As I recall the Navy had one point of view and the Air Force had another. You have mentioned here the alternatives but there was one thing that they suggested there. That was concerning a mixture. Mixture say with concrete, a different type of mixture where the cost would be less. Less cement in the mix, et cetera. Do you know anything about a pavement of that type?

Captain KEHART. Are you still speaking of all being concrete but of a different design, a different gradation or a different ingredient that goes into the concrete mix?

Mr. BATES. Different proportion, yes.

Captain KEHART. Well, only thing I can say along that line is there is continual improvement in the design of concrete pavement to withstand blast. The same is true of asphalt. I think that we know that the concrete at the present time is superior when it comes to the blast effects and to the high velocities and to heavy wear.

Mr. BATES. I am talking about cost, Captain. They seemed to indicate at that meeting, it is a little hazy now, I admit, but it is hazy too because they were very hazy at the time, we had considerable discussion about it, but they indicated that by having a different type of mix, that you could get almost the same performance for perhaps a third of the cost. Now are you familiar with anything along that line?

Captain KEHART. Well, the only thing I can say along the design of concrete is that we continually design so that we can get the cheapest concrete, cheapest per square yard concrete by reducing the

amount of cement and by getting aggregates that will meet the specifications and yet be the least costly. Now you will find in some areas that the cost of concrete aggregates are expensive and, from the designer's standpoint is absolutely necessary to have a certain number of sacks of cement in the mix, and the designer will not permit us to reduce the proportion and the type of concrete or the type of aggregate or the type of cement that goes into the mix.

He requires a certain strength.

Mr. BATES. Yes, but it is a question of what is needed. At that time it was indicated that a certain mixture was almost as good as this much more costly mixture which they had been making.

Captain KEHART. The only thing I can say for the Navy is that we do take the type of concrete that is the most economical and yet meets our strength requirements.

Mr. BATES. Mr. Chairman, Mr. Kelleher, counsel, was on that trip with us. He might be able to elaborate.

Mr. KELLEHER. I do remember the discussion and it was pretty inconclusive. Your recollection is correct that one of the witnesses, it is my recollection it was a Navy witness, said that development had gotten to the point where a much less expensive mixture would be equally as good as that being used then. I don't recall whether it was a third of cost or not but it was substantially less and just as good in performance.

Mr. BATES. You are not familiar with that, Captain Kehart?

Captain KEHART. I am not familiar with what you are trying to bring out there, no, sir.

Mr. BATES. You understand what I am saying?

Captain KEHART. I understand what you are saying. I understand you are trying to say that the design we use, under our requirement might be lessened.

In other words, instead of having a certain strength concrete we can reduce the concrete, the required strength and still meet the requirements of the aircraft.

Mr. BATES. I am talking about 2 years ago now.

Captain KEHART. Yes. Well I would say that probably our design today is let's say cheaper than it was in those days. I thing probably we might have had a higher strength. Do you know Mr. Palmer. We haven't changed our strength requirements in 2 years.

Mr. BATES. You have gone to other requirements.

Captain KEHART. Yes, because of the heavier planes. Yes, sir.

Mr. BATES. This is getting just as confusing as that meeting we had out there, Mr. Chairman.

Captain KEHART. I will say we have reduced thickness however. We have reduced the thickness of our pavement.

Mr. BATES. I am talking about the mix.

Captain KEHART. We do have a more economical mix or we wouldn't have been able to reduce the thickness. So maybe we have satisfied your question there. We have a thinner layer of concrete today than we had 2 years ago.

Mr. HESS. With the same strength?

Captain KEHART. Greater strength.

Mr. BATES. Greater strength but more concrete?

Captain KEHART. Less concrete in volume.

Mr. BATES. I am talking about per cubic inch.

Captain KEHART. Yes, greater strength per cubic inch.

Mr. BATES. And more concrete per cubic inch.

Captain KEHART. You can't have——

Mr. BATES. More cement.

Captain KEHART. More strength, yes, but less cement.

Mr. BATES. I thought you said it was more.

Captain KEHART. No; less cement. It is greater strength with less cement because we have improved the design mix.

Mr. BATES. Then you are getting back to specifically what I indicated a few moments ago.

Captain KEHART. That is right.

Mr. BATES. You have made progress.

Captain KEHART. Yes.

Mr. BATES. You are putting less cement in now than you did before.

Captain KEHART. That is correct.

Mr. BATES. Can we have something prepared as to what you have done?

Captain KEHART. We can have a statement showing the comparisons 2 years ago of the thicknesses of pavement we had and the amount of cement that we put in at that time and the amount of cement we use now and show the economy.

Mr. BATES. Per square foot.

Captain KEHART. Yes.

Mr. BATES. Per cubic foot.

Captain KEHART. Per volume; yes, sir.

Mr. HÉBERT. Does the Navy in letting bids, Captain, give any consideration in the combination of the asphalt and the concrete installations, where you have concrete combination, concrete in certain areas and the asphalt in others, in less critical areas, does the Navy give any consideration in its specifications to a differential of 5 percent in favor of the concrete or any percentage?

Captain KEHART. No, sir. We do not. We make an engineering analysis and an estimate of cost of both types at each location and—before we ask for bids—if we see that we can save money by using the noncritical areas in asphalt we then advertise for asphalt in the noncritical areas and concrete in the critical areas. We do not place the differential in our bids that you have mentioned.

Mr. HÉBERT. Are you familiar with what I am talking about?

Captain KEHART. Yes.

Mr. HÉBERT. And you do not have the same policy as the Air Force of giving a 5 percent differential?

Captain KEHART. No, sir.

Mr. HÉBERT. Did you ever consider that?

Captain KEHART. We have considered it only in specific instances where we thought that the two costs were comparable. We have considered that but we ran into the considerable amount of bickering after the bid was let as to the low bidder. In other words, if you have a low bid that favors asphalt but the cost of the concrete is a very small percentage more, then we would want to put it in concrete.

Mr. HÉBERT. Why?

Captain KEHART. Concrete would be more economical. In other words it would be a tendency to award it to concrete.

Mr. HESS. You say asphalt is just as good as concrete in that noncritical area?

Captain KEHART. Yes, it is.

Mr. HESS. But you award it to concrete.

Captain KEHART. I am considering it is as good when you take all the factors of economy and maintenance into consideration. I say yes.

Mr. HÉBERT. Yes to what?

Captain KEHART. I say that they are comparable when you take all of the facts into consideration. But if I thought that a field would be immobilized and I had a bid for both, I certainly would go into concrete. If it was going to be immobilized and I knew I would need it at a later date.

Mr. HÉBERT. Immobilized in what way?

Captain KEHART. Not used for a period of 5 or 6 years and then used in case you needed it, as an additional airfield and were holding it in let's say reserve for mobilization.

Mr. HESS. The concrete would stand up better.

Captain KEHART. It would stand up better during the immobilized period. Whereas asphalt you have to go in and reconstruct that whole area.

Mr. HESS. Wouldn't it be true that the maintenance cost on asphalt would be higher than on concrete if what you say is true?

Captain KEHART. If you call that immobilized period, that reconstruction cost a maintenance item.

Mr. HESS. It is maintenance, isn't it?

Captain KEHART. I call it a new construction. If you are going to put a new surface on it.

Mr. HESS. You wouldn't have to do anything with concrete?

Captain KEHART. You would have to——

Mr. HESS. The joint wouldn't separate.

Captain KEHART. You would have to refill the joints, take the joining material out and refill.

Mr. HESS. Wouldn't it take just about the same amount of time to resurface asphalt?

Captain KEHART. Those joints you know are just at intervals and are not as expensive as the whole surface as asphalt for the whole area.

Mr. HÉBERT. In the ultimate it is dollars isn't it?

Captain KEHART. Yes. That is the reason and it is a very important factor with us. That is the reason if the asphalt is cheaper in our engineering estimate we go to asphalt for the noncritical areas.

Mr. HÉBERT. I am looking at the long range picture—what may be cheaper here in the beginning may be more costly in the end. .That is why we have asked questions about the maintenance. You say you have no valid records.

Captain KEHART. For two fields that are used continuously. One constructed of concrete, one of flexible—we do not. Talking about mobile fields.

Mr. HÉBERT. But the immobile fields you do have valid records?

Captain KEHART. Yes. We have had to rebuild those and we have had to spend a lot more money rebuilding asphalt fields than we have the concrete fields.

Mr. HÉBERT. Would you say that it would be a proper conclusion that where you do have the valid records on the immobile fields, that

those valid records indicate that asphalt is more costly than concrete?

Captain KEHART. Well——

Mr. HÉBERT. Let's get some conclusion—not one of these nebulous conclusions.

Captain KEHART. Well you are trying to pin me down.

Mr. HÉBERT. Yes.

Captain KEHART. To a maintenance factor. I consider a field is immobilized when you go back to rebuild that field not an item of maintenance—it is an item of construction.

Mr. HÉBERT. Whether you call it construction, maintenance, rearrangement, it still costs dollars. We are interested in dollars.

Captain KEHART. My statement still holds——

Mr. HÉBERT. I don't care what you call it.

Captain KEHART. My statement there in the record still holds, that if a field is definitely going to be immobilized and later on reused, that it is less costly to have concrete than asphalt.

Mr. HÉBERT. In other words, in fields where a construction is to eventually be in a standby status, where you know you will imobilize them in time of less emergency; then you would there from your experience, which you consider valid, recommend concrete instead of asphalt?

Captain KEHART. I would.

Mr. HÉBERT. Thank you.

Mr. HESS. Mr. Nelson.

Mr. NELSON. I dislike to take the committee's time, but I would like to get these facts. I would suggest that the captain do file with the committee the examples of the damage that he has had due to jet operation.

Mr. HESS. Captain, will you furnish that, please?

Captain KEHART. I will do that.

Mr. NELSON. Captain, in reactivating these fields, you have the cost records, do you not?

Captain KEHART. Yes.

Mr. NELSON. Will you give this committee examples of fields that you had to reactivate and what it cost for an asphalt and the cost for concrete?

Captain KEHART. I am not sure we have any for concrete. Most of the ones that we reactivated were the satellite fields that we built during the last war and probably all of them, I can't make a positive statement, were of asphalt.

Mr. NELSON. How do you have anything to compare the costs, then, Captain?

Captain KEHART. We do have some areas, some portions of fields of concrete that were reactivated. We do have some records of cost. Whether the figures we give you would be conclusive, we are not sure, that it will mean too much. But we are willing to give you any records we have, sir.

Mr. NELSON. The thing that bothers me is that you made the definite statement that it was much cheaper to reactivate a concrete field that had been in disuse for sometime than it was as an asphalt field. All that I want to know is what facts you have to substantiate the statement you have made? I think the committee would be interested in having those facts.

Captain KEHART. Well, let's say that that statement probably was influenced by my background in engineering and construction; that I have seen a lot of asphalt that has been immobile for a long period of time, and also some concrete pavements that have been immobile for long periods of time.

Mr. NELSON. Then that is experience that you yourself had and not actual experience that the Navy has had?

Captain KEHART. I would say also that the people that are working with me have had the same experience.

Mr. NELSON. Now, Captain, which do you find that you have the most damage from, spillage or from blast?

Captain KEHART. I would say that today we have more damage from blast effects than from spillage.

Mr. NELSON. How much damage have you had from fuel spillage?

Captain KEHART. We don't have any evidence or records from spillage in our modern pavements. First, there is a little more caution, the planes are better designed so as to eliminate that, and also we haven't had the experience that spillage does cause a great deal of damage to the modern fields that we have recently finished.

Mr. NELSON. Isn't it true that by good housekeeping you can eliminate spillage almost entirely?

Captain KEHART. We have eliminated it a lot.

Mr. NELSON. How much does that cost the Navy; very much?

Captain KEHART. I couldn't tell you and I doubt we could get any figures on that, sir.

Mr. HESS. You have cut it down to a minimum aboard carriers.

Captain KEHART. We have to, yes, because carriers are like comparing the inside of your house with the outside of the house; you will be a lot more cautious with fire on the inside of the house. On a carrier you can't afford to have a fire of any kind.

Mr. HESS. You are more cautious on the fields too, aren't you?

Captain KEHART. Yes, but you are not as cautious outside in your yard as in your house. It is just the psychological effect I would say.

Mr. NELSON. How much experience, Captain, has the Navy had with blasting?

Captain KEHART. Considerable experience. We have some records on that.

Mr. NELSON. Can you give this committee data on the number of instances of blast damage to asphalt pavement as compared with concrete, and how much was damaged?

Captain KEHART. We can give you considerable data, yes. I don't know just how extensive it will be.

Mr. NELSON. I would like to request that the captain furnish that, Mr. Chairman, to the committee.

Mr. HESS. If you will, Captain, please.

Mr. NELSON. Would you tell us, Captain, what the Navy's definition of critical areas is; what are they?

Captain KEHART. The critical areas for the Navy where we pave in concrete—in portland cement—with portland cement concrete—are the ends of the pavement, ends of runways, ends of the taxiways, all parking areas and all fueling areas.

Mr. NELSON. What footage on the end of runways?

Captain KEHART. Today it is—we are maintaining 500 feet.

Mr. NELSON. 500 feet on the end?

Captain KEHART. On each end.

Mr. NELSON. Where do the Navy's planes warm up, on the end of the runway?

Captain KEHART. Both on warmup aprons and the end of runways.

Mr. NELSON. You require them to be built of concrete?

Captain KEHART. Yes, that is right.

Mr. NELSON. Now, Captain, when you prepare the design for an airfield and have decided that asphalt could be used in noncritical areas, do you ask both the concrete industry and the asphalt industry to bid on it, or do you specify that it shall be asphalt and only asphalt can bid?

Captain KEHART. Today our practice is to specify only asphalt in the noncritical areas, unless we find by preliminary engineering analysis and study that concrete is as cheap or cheaper.

Mr. NELSON. That is, the Navy makes its own estimate on what the low bid would be and specifies that material?

Captain KEHART. We make an engineering analysis, field analysis, engineer estimate, and then we decide, and that is the way we bid. We bid on the cheapest combination, either combination of asphalt for noncritical and portland cement or all portland cement, whichever is cheaper for the area.

Mr. NELSON. Do you get any blast damage at all from the moving plane?

Captain KEHART. We have found from the experience with certain speeds that we have not had too much damage. That is so far.

Mr. NELSON. How long must a plane be operated in one spot to cause this damage?

Captain KEHART. I think it all depends on what the plane does. If it lets off, the blast damage is done in a few seconds. And it all depends on just the, you might say the angle of the engine on the pavement and the pilot's discipline, and so forth. It is variable. I don't believe you can make a positive estimate on that.

Mr. NELSON. That is all.

Mr. HÉBERT. May I ask a question—Mr. Nelson, I think, asked which areas do you consider critical. I don't think you answered that.

Captain KEHART. Which areas?

Mr. HÉBERT. Yes.

Captain KEHART. I did, but I will be glad to repeat it. The ends of the runways, the ends of the parallel taxiways, and all of the parking and warmup areas and the fueling area.

Mr. HÉBERT. How does that differ from places the Air Force considers critical?

Captain KEHART. I think our practices in that respect are the same. However I think the Air Force would be in better position to give you that.

Mr. HÉBERT. I just wanted to eliminate a lot of talking to other people. I though you might know.

Captain KEHART. I think it is about the same. They may have larger, requirement for larger parking areas, and so forth, in fueling areas, because of the size of planes and the number of planes.

Mr. HÉBERT. But the fundamentals are practically the same?

Captain KEHART. I would say they are about the same, sir.

Mr. HÉBERT. May I ask the Air Force; could they tell us that now?

Mr. FERRY. We agree on that.

Mr. HÉBERT. They are the same.

Mr. FERRY. Yes.

Mr. FISHER. Will the gentleman yield?

Mr. HÉBERT. Yes.

Mr. HESS. Mr. Fisher.

Mr. FISHER. You referred to the—as a part of the critical—so-called critical area—the end of the runway. What do you mean by that, what length would you say, the average runway?

Captain KEHART. Our present practice is 500 feet, sir.

Mr. HÉBERT. At either end?

Captain KEHART. At both ends.

Mr. HÉBERT. If it is a 6,000-foot runway, for example, you would want 1,000 of that classified as critical?

Captain KEHART. That is correct, sir. Although, I might add that about a year ago we were at a thousand feet and then due to the—let's say the scarcity of money and austerity that we have gotten into—why, we have gone back to 500 feet. We think it is ample now. We hope it is in the future.

Mr. HÉBERT. Does the Air Force agree with that?

Mr. FERRY. No, sir, we don't.

Mr. HESS. Mr. Nelson.

Mr. NELSON. Captain, most of the Navy's first-line fighters, as I understand it, are made by Grumman Aircraft; is that correct?

Captain KEHART. Let's see if we can get our airman. Would you repeat that question?

Mr. NELSON. Most of the Navy's first-line fighters are constructed by Grumman Aircraft, are they not?

Mr. MOE. I am not too sure. We have the McDonald and the Grumman and other types of aircraft. Lockheed, and so forth. Whether the Grumman is the most-used airplane, I am not in position to say. These models keep coming out all the time. We have the F–7, U—which is a Chance-Vaught. That is, it is not a matter of the number of aircraft. It is the type of aircraft and it is in relation to the runway that makes the difference.

Mr. NELSON. Mr. Chairman, I think it may be assumed that—from my own knowledge, at least—that Grumman manufactures a good proportion of the jet fighters for the Navy.

I would like to ask the captain, in view of that, if he knows the construction of Grumman of the airfield at the Grumman plant.

Captain KEHART. The field at Beth Page was built under, you might say, Navy specifications, at least under our guidance. And that, I think, is their largest field.

That is probably their largest operating field. We did—you might say, are the inspection agency for anything that Grumman built in that plant to the credit of the Navy.

Mr. NELSON. It is almost completely asphalt, is it not?

Captain KEHART. Good deal of it. I think you will find the ends are concrete. I don't recall now. I was in New York at the time it was built. But I am pretty sure that the ends are concrete. I would have to check that, sir.

Mr. HESS. Mr. Hardy.

Mr. HARDY. One question, Mr. Chairman. I am sorry I missed the earlier part of the captain's testimony.

The point I want to make is this: The captain said awhile ago they made an engineering estimate to determine whether to specify asphalt or concrete on the proposal. Do you ever run across the situation in which the engineering estimate as between the two were reasonably close?

Captain KEHART. Yes.

Mr. HARDY. What do you do in that case?

Captain KEHART. Well, let's say that an engineering estimate, if it is practically the same, we know it is liable to be about 5 percent off of the actual building estimate. Bidding estimates are final, you might say, determined by several factors; depends on how hungry the contractors are, the materials situation, depends on the factors that we can't anticipate.

Mr. HARDY. I was going to ask you whether or not you had gotten to the point where you could read the mind of the contractor.

Captain KEHART. Let's say we can guess pretty close. If asphalt is estimated to be cheaper why we go to asphalt.

Mr. HARDY. You do it entirely on the basis of your own guess and not on the basis of alternative bids?

Captain KEHART. That is correct.

Mr. HARDY. Did it ever occur to you that you might guess wrong sometime or are you infallible?

Captain KEHART. No, we have been wrong, sir.

Mr. HARDY. You wouldn't ever find it out and nobody else would if you didn't submit alternative bids?

Captain KEHART. Let's say, Mr. Hardy, that in most cases we have found that asphalt is cheaper and rather than go to the expense of designing for both, we go automatically to the asphalt. It has been only in a few cases where we have found it is cheaper to build in concrete. We would waste a lot of money, we feel, if we in every instance advertised for both.

Mr. HARDY. Well, one other question. I was interested in your observation made about the time I came in that a field that would have to be used as standby, have to be reactivated, you always wanted to use concrete.

Captain KEHART. Well we say that it would be cheaper to reactivate if it was concrete instead of asphalt.

Mr. HARDY. Regardless of the climate?

Captain KEHART. Regardless of the climate?

Mr. HARDY. That is my question.

Captain KEHART. I would say—well, my own personal opinion is yes.

Mr. HARDY. That is all.

Mr. HESS. Any other questions?

Mr. NELSON. You also said that the Navy had no experience to base that conclusion on, it was your own conclusion from your past experience.

Captain KEHART. We have had enough experience on let's say flexible pavement. We have enough experience to know we have had to go in—in almost every case—to go in and resurface the pavement.

Mr. NELSON. But you have no experience on concrete to compare that?

Captain KEHART. We have some.

Mr. NELSON. Let's get it.

Captain KEHART. Well——

Mr. NELSON. You said a while ago you had some.

Captain KEHART. No, I told you we had some areas on which we could furnish data.

Mr. NELSON. Will you furnish us that data?

Captain KEHART. I will do that.

Mr. HESS. Mr. Hébert.

Mr. HÉBERT. Captain I would like to pin down these critical areas. As I understand it the criteria for the Air Force specifies that portland cement concrete must be used on these areas. I will enumerate them and will you check them?

No. 1; all apron areas including access ramps, to hangars or docks.

Captain KEHART. Yes, sir.

Mr. HÉBERT. No. 2, stub parking, hardstands.

Captain KEHART. Yes, sir.

Mr. HÉBERT. Three. Wash racks.

Captain KEHART. Yes, sir.

Mr.HÉBERT. Four. Calibration-racks platforms.

Captain KEHART. I don't think we have—we don't have too many of those, if any. I don't know.

Mr. MOE. We do. We have a calibration hardstand. We call it a compass row.

Captain KEHART. The answer is yes.

Mr.HÉBERT. Five. Warmup areas.

Captain KEHART. Yes.

Mr.HÉBERT. Six; runway ends?

Captain KEHART. Yes.

Mr.HÉBERT. Five hundred feet for the Navy, a thousand for the Air Force? Is that correct?

Captain KEHERT. Navy is 500.

Mr.HÉBERT. You don't add to that at all? Six encompasses your whole criteria?

Captain KEHERT. Fueling areas we have.

Mr. HÉBERT. You have an additional one then?

Captain KEHERT. Unless they put their fueling areas in one of those other categories.

Mr. HÉBERT. Did you, Mr. Ferry?

Mr. FERRY. They call that the apron. They include that in the apron.

Mr. HÉBERT. They include it in apron. And yours is the two categories.

Captain KEHART. Yes.

Mr. HÉBERT. It amounts to the same thing.

Captain KEHART. It is the same thing.

Mr. HÉBERT. That is all.

Mr. HESS. Mr. Courtney.

Mr. COURTNEY. Is it Navy practice to require a single bid for both concrete and asphalt from the same contractor, where you elect to divide the areas between the so-called critical and noncritical areas?

Captain KEHART. The same contractor usually gets the bid.

Mr. COURTNEY. Is he required to bid on the whole job?

Captain KEHART. Yes, usually.

Mr. COURTNEY. You don't permit breakdown?

Captain KEHART. Usually, unless we bid at different times. Then some other contractor is liable to come in and do the work.

Mr. COURTNEY. As a matter of fact, Captain, there is very little of the experience that you had 2 years ago that would be—that would be valid today with the change in the type of aircraft, isn't that correct?

Captain KEHART. I would like——

Mr. COURTNEY. There would be very little experience which you had with respect to airfields built say 2 years ago which would be valid today?

Captain KEHART. That is correct.

Mr. COURTNEY. With the type of aircraft?

Captain KEHART. That is right.

Mr. COURTNEY. Yes.

Captain KEHART. Too short a time.

Mr. COURTNEY. That I think is the first part of your statement. That is all, Mr. Chairman.

Mr. HESS. Any other questions? If not, thank you very much, Captain.

Mr. COURTNEY. With the addition of that matter we will close the Navy's testimony.

Mr. HESS. Unless they have any other testimony.

Captain KEHART. Nothing else.

Mr. COURTNEY. Mr. Chairman, Mr. John Ferry is here from the Department of the Air Force.

Mr. HESS Mr. Ferry, we will be glad to hear you.

STATEMENT OF JOHN FERRY, SPECIAL ASSISTANT FOR INSTALLATIONS, OFFICE, SECRETARY OF THE AIR FORCE

Mr. FERRY. I am John M. Ferry, special assistant to the Secretary of the Air Force. I appear before you today to discuss the requirements of the Air Force with respect to runways, taxiways, parking aprons, and similar types of paving required for our base. While my design experience is limited in respect to pavement, since I am a mechanical, not a civil engineer by profession, I have been connected with the construction industry for over 25 years and during the war I was deeply involved in both the design and construction of airfield pavings for what then was the Air Corps in the West Indies. I would hesitate to claim any real design competence but am familiar in broad terms with the problems of paving.

Paving for modern aircraft are of two types—rigid, which means constructed of portland cement concrete—and flexible, which is an asphalt topping over a subgrade of properly prepared stone base. Both types of pavement are in common usage and until the advent of the jet engine for aircraft propulsion, either pavement would adequately perform its function, assuming it was properly designed for strength, drainage, etc. The increased use of jet aircraft has introduced a number of new problems such as the effect of the hot blast from the tail of the plane, and the high velocity of these hot gases and the fuel drippings from the engines which occur under certain conditions of starting and stopping engines and during periods of low combustion.

I would like to explain in this connection with this fuel dripping—I do not know if it is clear to the committee.

It is not drippings just when you fuel the airplanes, just when the hose goes into the fuel tank. As the engine starts up, a jet engine, it spills out the tailpipe a couple, maybe 2 gallons of this jet fuel, during periods of low combustion, for example, when it is taxied, it is apt to drip some of the fuel which is not properly burned.

During the period when the engine is slowed down, after stopping, we get some spillage out of the tailpipe.

So that this spillage is beyond the spillage that occurs as you fuel the plane.

Mr. BATES. The same as an automobile?

Mr. FERRY. Only it lets out a big slug of it.

Mr. BATES. But it is the same type.

Mr. FERRY. It is this petroleum kerosenelike stuff.

I return to the prepared statement.

We have found, in a relatively short period of time, that the effect of both the blast and the heat as well as the spillage has severely detrimental effects on asphalt paving. As a result of these experiences the Air Force changed requirements in August of 1952 so that the paving at new fields provides for concrete parking aprons, warmup pads, and the ends of the main runways. The other portions of the runways and the taxiways would, we expected, be satisfactory if either asphalt or concrete were used.

As a result of repeated reports from the field commanders, a number of which I have available here for the information of the committee, it shortly became apparent that an all-concrete design offered certain advantages in view of the progress toward a jet-powered Air Force. In other words, given a free choice of asphalt or concrete, the Air Force would prefer concrete if the cost of the concrete were within a comparable price range of asphalt paving. It must be apparent to you gentlemen, all other things being equal, that the permanency and lower maintenance cost of concrete give the most desirable characteristics over a long period of years; the only critical point being the question of how much we could afford to pay for these advantages.

Our records of paving maintenance cost over the short period of time we have been using jet aircraft is insufficient and inadequate to allow a good evaluation record. From an engineer's point of view a conclusive picture cannot be formed over such a short period of observation but it is clear to us in the Air Force that good engineering judgment justifies some premium for concrete above the first cost of asphalt paving.

Since the comparative cost of concrete paving and asphalt paving varies from location to location and from job to job, depending upon geography, soil conditions, and availability of aggregate, etc., we have established a principle that we will obtain comparable cost figures for the two types of paving on any new areas and that we are justified in paying a premium of up to 5 percent to secure the advantages that are apparent to us with the concrete-type paving.

I would like to repeat to you gentlemen that there is no firm engineering data, cost analysis, or experience to back up this conclusion. With only a short experience with jet power we are now in the position of building for the long-range requirements for the Air Force and

it is our best judgment that a 5-percent premium seems justified in view of the reduction in troubles, the indicated reduction in maintenance cost and the probable longer uninterrupted service that could be secured as against using asphalt paving or a combination of both types.

Please bear in mind that these remarks apply only to our criteria for new bases. Where there are existing runways at presently constructed bases and the requirement is to strengthen, improve smoothness, lengthen or widen these runways the type of paving to be installed would be decided upon an individual basis after examination of the pertinent facts in each case.

We are continuously exploring means to avoid restrictive provisions in specifying types and areas for our pavements. Proprietary protective coatings for asphaltic pavements have been tried without success. Experimental work has also been initiated in the interest of reducing the cost of concrete pavement. We are at present collaborating with industry in the development of a tar-rubber paving mixture that shows considerable promise. If proven adequate as a surfacing, use of such material would permit underlying pavement courses to be constructed of asphalt.

Pending a favorable solution to the problem, we have no option but to proceed with airfield pavement construction in accordance with current criteria.

To depart—that is the finish of the formal prepared statement—I would like to bring it down as I see it to a very simple comparison. You put a roof on your house, you can put a wood-shingle roof on or you can put a 20-year tar and gravel roof on the same house. Both will keep the rain out, both will last quite a while, but I thing it is common knowledge that you will have more maintenance cost with the wood shingle roof than with the 20-year bonded tar and gravel roof.

In making the decision you would be justified, I believe, for your own house in choosing the roof that will give you the least maintenance cost over the period of time you hope to live in it, even though the first cost might be slightly in excess of a wood-shingle roof.

Again to illustrate, in your kitchens, you can put down an asphalt tile floor, as one of the cheaper of floor coverings, very good, very good until you spill grease on it. Then it goes to pieces.

So that you are justified there in putting down a linoleum or linotile which is resistant to grease even though the first cost may be somewhat in excess of asphalt tile.

Mr. HESS. Any questions?

Mr. HÉBERT. Your statements, of course, are logical and your conclusions are necessarily logical. The fact is that the asphalt people disagree with you. Do you have any comment to make in this connection?

I am sure you are familiar with the contention of Americal Asphalt Institute, I think it is. Specific questions were asked them yesterday regarding maintenance and they made the dogmatic reply that the maintenance was equal in both.

Do you have any figures as to that? Any figures that would contest that statement?

Mr. FERRY. I have no figures, Mr. Hébert. As I pointed out, our experience is too short. No maintenance figures, adequate engineering cost figures, are available.

I do know, in connection with the brochure put up yesterday by the Asphalt Institute, that on page 3 they make a number of statements which indicate that they expect damage. I read here—

in our opinion there is no evidence of excessive damage,

from which one might read that they expected some damage.

While it is true there is evidence of some softening where excessive fuel spillage occurs, this is only a temporary condition.

We do not agree. We have evidence to the contrary.

Mr. HÉBERT. That is what I am directing my questioning to. You do have evidence that that statement is not correct?

Mr. FERRY. Yes, sir.

Mr. HÉBERT. Would you give the committee the benefit of that evidence?

Mr. FERRY. I will have to call upon my experts here, whom I have here, to back me up for actual specific instances, because my own inspection of these fields is too limited.

Mr. HÉBERT. So long as it is valid information.

Mr. FERRY. At Andrews Field, which I have seen myself, close to Washington here, I have seen evidence on the ends of asphalt runways, where the fighters were standing, close to where they were standing, of damage that; it has crumbled away due to fuel spillage. It has not returned to its original condition. I have seen that on a number of other fields but I would hesitate at this moment to specifically name them because my memory is not too good.

Mr. COURTNEY. Andrews Field is a big case in point. Was the paving laid out there being used for jet fighters or was it laid for another type of aircraft?

Mr. FERRY. I believe, sir, that it was originally a gasoline-engine field.

Mr. COURTNEY. So it is not a pavement at Andrews Field which you would say would be adapted or which you would design for jet aircraft?

Mr. FERRY. Because of the fact that it is asphalt, sir.

Mr. COURTNEY. In any event, with the criteria that you have used—if you were to go to asphalt—would not be the same as Andrews Field today?

Mr. FERRY. No, sir.

Mr. COURTNEY. As it is at the present time?

Mr. FERRY. That is correct.

Mr. COURTNEY. As it was originally laid, is what I mean to say.

Mr. FERRY. Yes.

Mr. COURTNEY. Mr. Ferry, what experience has the Air Force had with other materials in combination with asphalt or even concrete, to meet the problems created by spillage and blast?

Mr. FERRY. I know of no known pavements other than concrete or asphalt. We have, however, tried proprietary paintings of materials on the surface of asphalt pavements in an attempt to protect them from this spillage, if that is what you are referring to.

Mr. COURTNEY. I was thinking of that and also of the developments that have been carried on by the, I think, the United States Rubber Co.

Mr. FERRY. Yes, sir.

Mr. COURTNEY. And the Flintkote Co.?

Mr. FERRY. Yes.

Mr. COURTNEY. Both of whom are represented here today.

Mr. FERRY. Yes.

Mr. COURTNEY. Have you had any experience upon which you could predicate a conclusion as to the adaptability of those combinations with any other base material?

Mr. FERRY. I do not have sufficient data on which to prophesy the actual life and available use of these substitute materials you mention. There are indications, however, that a tar-rubber combination is going to become a very valuable thing. It is not conclusive.

Mr. COURTNEY. I notice in the brochure presented yesterday here a bid was taken, I think in McChord Field, where the price of the combination asphalt and this material of the rubber company was something like $4.16 a cubic yard as against a competitive bid of all-concrete of something like $6.07. I may be off a few cents.

Mr. FERRY. I am not familiar.

Mr. COURTNEY. Beyond that, do you have any familiarity with this project?

Mr. FERRY. No; I disqualify myself there.

Mr. COURTNEY. That is all.

Mr. HESS. Mr. Ferry, you were making comparisons of roofing material and floor coverings, things of that sort, talking about maintenance costs, then comparing asphalt with concrete pavement as to maintenance cost. That has held true for quite some years in the past, hasn't it, if you say it is true now, that the maintenance cost of concrete is a great deal less than that of asphalt?

Mr. FERRY. Yes.

Mr. HESS. That was true 5 years ago; it was true 10 years ago?

Mr. FERRY. Yes.

Mr. HESS. At that time we constructed our airfields out of asphalt almost entirely.

Mr. FERRY. At that time the effects of the modern jet aircraft with hot gases and spillage of fuel had indicated that we could get along thoroughly satisfactorily with asphalt pavement.

Mr. HESS. Yes.

I am inclined to agree with you that there are critical areas where at the present time we are going to have to have concrete unless we find something that will answer the purpose better in the future, but we don't have that problem on the runways, the question of spillage, or the question of blast damage?

Mr. FERRY. We do, though, sir.

Mr. HESS. In the center portions?

Mr. FERRY. Yes. It is minimized because the fuel spillage in the center of the runway is generally a relatively minor affair. The blast action is still there, however. As the planes take off and they point the tail-pipe downward, the runway—as they take off you get a scorching action.

Mr. HESS. I agree with you there. That would be the reason for your thousand-foot critical area to be built in concrete.

But after the tail of the plane raises up and she starts down the runway there is not any blast damage then, is there?

Mr. FERRY. Yes, there is in certain types of planes. The engine, the jet engine, is set at an angle so that its blast action is downward,

and may land on the portion of the runway beyond the thousand-foot concrete.

Mr. HESS. Mr. Fisher.

Mr. FISHER. Mr. Ferry, you have indicated that 5 percent range with regard to the cost of asphalt and concrete.

Mr. FERRY. Yes.

Mr. FISHER. And you have stated that the field was justified in granting the contract for the construction of asphalt—I mean, to concrete—provided it didn't cost more than 5 percent?

Mr. FERRY. That is right.

Mr. FISHER. As compared to that?

Mr. FERRY. Yes.

Mr. FISHER. Now, there has been a little confusion here in the record about that. Let me give you a hypothetical case and see if I understand exactly how that would be applied:

Suppose there is a contract for a 6,000-foot runway. Suppose you eliminate 1,000 or 2,000 feet. Let's eliminate the critical area, whatever it is. Suppose we then have 4,000 feet of so-called noncritical runway, and then suppose the asphalt bidder bids $4 per square yard. If the concrete man bids 5 percent above that it would be $4.20, wouldn't it?

Mr. FERRY. Yes.

Mr. FISHER. He would not get the contract. Under your criteria it would go to the asphalt. Is that the way that is applied?

Mr. FERRY. Not quite, sir. I would like to clarify that. We take, or have our construction agency, which is the Corps of Engineers, take a bid for the completed paving, which includes the ends, the concrete ends, the asphalt in the center, the concrete paving aprons, as one lump sum, a completed paving contract.

Mr. FISHER. You never have a divided contract of noncritical and critical?

Mr. FERRY. No, sir. We attempt to take one overall figure so as to eliminate bickering about awarding the contract. In other words, here is a lump sum that the contractor says, "I will build what you want for that money."

Mr. FISHER. It would seem to me offhand without knowing too much about the subject that it is a divisible sort of a contract which if applied in this way might save a lot of money, by granting contracts for the critical in one contract and the noncritical in another. Do you agree with that?

Mr. FERRY. There is a possibility, sir, that we could save some money.

Mr. FISHER. Well, we have had examples here of where the asphalt people, say, would bid $4—these are not actual cases, I am just mentioning them—and concrete $6.

That is on the so-called noncritical, the part where you are willing to accept asphalt and it would be capable of meeting your requirements.

Obviously there would be a considerable saving there, with respect to that noncritical area, that is, if the asphalt went into that part, and the concrete was applied to the so-called critical area.

It seems to me, overall, it might run into many, many millions of dollars.

Mr. FERRY. We had the same view, sir, prior to our recent change of criteria. In fact our airfields have been in the last several years, last year, have been designed on that basis, but we have had repeated and vehement complaints among field commanders which I might mention they have advocated paying premiums up to 10 percent for all-concrete pavement, which has indicated to us that there are sufficient matters in the all-concrete pavement that we are justified on a plain engineering judgment basis to pay some premium. Now, it is a question of judgment whether 5 percent is the right sum.

Mr. FISHER. I am not quarreling about the validity of the policy with respect to allowing some differential there, as an advantage to concrete, from your viewpoint, but the point I was making is whether it would be feasible to divide the two contracts, one the critical and one the noncritical and eliminate a lot of this discussion and dissension with respect to the relative uses of both, and that way get the very best that asphalt could provide at the lowest possible price, in this bidding, and at the same time let the so-called concrete bidders who will deal with the critical areas, bid on that part of it.

I am just wondering about the feasibility of dividing the contract and eliminating a lot of this.

Mr. FERRY. It is feasible. We would prefer from an administrative point of view to have one paving contractor on the field. It is an advantage to a job to have one head who is doing all the work. They are too many to bother enumerating, but there are many. So we would prefer to award the contract for the pavement to a contractor.

Mr. HARDY. Could you do that and still have a divided bid? You have an awful lot of subcontractors. Couldn't the prime contractor have a subcontractor doing the asphalt?

Mr. FERRY. Yes. I pointed that out in my discussion, that we used to do just exactly that. We would have concrete in one part and in the noncritical area, the center of the runways, the taxiways, we would use asphalt there, put down by the prime contractor.

Mr. HARDY. Obviously, if you are using 5 percent, or any percentage variation, and apply it to the whole contract, you are not going to get very much business with asphalt unless you are in a most unusual area.

Mr. FERRY. Sir, I don't think that is quite true, because we have indicated estimates right now where the indications are that we will save 15 percent.

Mr. HARDY. It depends on the type of work that you are doing, the type of contract that you are letting. If you are letting a contract for a whole field or runway, the parking areas, the aprons, all that business, at one time, then a percentage of concrete paving as related to the percentage of asphalt paving would be one thing, but if you are letting a contract for parking aprons or for hard stands, or for widening of a runway, you would come into an entirely different percentage relationship, as between the two.

Mr. FERRY. You are right, sir, but I pointed out in my testimony, my prepared statement, that we were talking about brand new fields. I said we went in to start a brand new field.

Mr. HARDY. Your 5 percent proposition applies only to a complete field.

Mr. FERRY. That is right, sir.

Mr. HARDY. How did you separate all the other where you are making substantial alterations to a field?

Mr. FERRY. If we were making substantial alterations to an existing field, sir, we would then examine the individual case to see where the necessities were for concrete.

Mr. NELSON. Mr. Chairman.

You arrive at your 5 percent differential just by comparing bids for pavement on a new field?

Mr. FERRY. Yes.

Mr. NELSON. Are you familiar with the bid on Plattsburg Airbase in New York?

Mr. FERRY. No, I am not.

Mr. NELSON. Is there anyone here could give us information on that?

Mr. FERRY. I have witnesses behind me, sir. If you would like to have them now——

Mr. NELSON. I call your attention, Mr. Ferry, to the brief submitted by the Asphalt Institute, exhibit A, page 6.

Mr. FERRY. Yes.

Mr. NELSON. The answer I want is as to the note at the foot of the page which says:

If pavement alone had been let to low bidder on asphalt savings to the Government would have been $2,166,000.

Mr. FERRY. Where is this, please?

Mr. NELSON. Page 6 of exhibit A. I am reading from the note at the bottom of the page.

Mr. FERRY. Yes.

Mr. NELSON [reading]: A difference of $328,817 between low bids does not reflect the true difference between pavement types because as in this case several million dollars worth of other items subject to unbalanced bids were thrown into the same contract.

Mr. FERRY. I have never seen this before, sir.

Mr. NELSON. I just call it to your attention to tell you that I would like to get the answer.

Mr. FERRY. May I point out one thing which I note. The figure in the last column at the right says $2,166,602 total saving. This airport if all asphalt were used—perfectly obviously we can't use all asphalt on a parking apron.

Mr. NELSON. I think you will find if you add the items that could have been done in asphalt which are the noncritical items according to the Air Force Director and also add items that are critical and had to be concrete that you find that there is much more than a 5 percent difference in the cost of asphalt, and you must have reduced the 5 percent differential by putting other things into your comparison before you took the 5 percent.

Mr. FERRY. It is possible. I am not able to answer the question so I will have to put it in the record.

Mr. NELSON. I understand that, but my question was, you arrived at 5 percent differential only by comparing bids on pavement?

Mr. FERRY. Yes.

Mr. NELSON. And it doesn't indicate that that was done at Plattsburg.

Mr. FERRY. That is my understanding of the criteria. Pavement alone.

Mr. NELSON. Now, do I understand, Mr. Chairman, that Mr. Ferry is going to produce witnesses to testify as to the reaction they got from the field commanders and to specific items of damage done by blast?

Mr. FERRY. Yes, sir.

I would like to start by reading in here some extracts from our field commanders——

Mr. HARDY. Mr. Chairman, may I ask a question first?

Mr. BATES. Yes, Mr. Hardy.

Mr. HARDY. Mr. Ferry, in your statement you refer to your policy, 5 percent policies, we call it, and you said you have established a principle that will obtain comparable cost figures for the two types of pavement.

Mr. FERRY. Yes.

Mr. HARDY. Now, does that mean then that you prepared your specifications for alternative bids?

Mr. FERRY. That is right.

Mr. HARDY. Do you present specifications for both asphalt and concrete?

Mr. FERRY. That is right, sir.

Mr. HARDY. How much does that increase your engineering cost?

Mr. FERRY. It runs up probably some $5,000, maybe $10,000, per job.

Mr. HARDY. Compared to the total cost of the job, percentage wise it is not much?

Mr. FERRY. Negligible.

Mr. HARDY. I was interested in that particularly because of the testimony of Captain Kehart. Have you ever tried making an engineering estimate to determine the relationship between the cost and using that as the basis for your decision?

Mr. FERRY. We do not do that, sir. We feel that because we have not our own constructing capabilities, the work being done, as you are aware, by the Corps of Engineers or by the Bureau of Yards and Docks, that we are not in a position to back up and substantiate an engineering estimate when it is a matter so very close as this.

Mr. HARDY. You don't think you could read the contractor's mind, then?

Mr. FERRY. That is right, sir. We are not conversant with the local field conditions and the availability of equipment and the availability of aggregate. We just don't know. We can't judge that close.

Mr. HARDY. The cost—the actual additional cost of engineering—you consider as inconsequential?

Mr. FERRY. We think it worth doing in the interest of economy.

Mr. BATES. Mr. Nelson.

Mr. NELSON. Mr. Ferry, you say in your statement you have not had as complete an experience in the two pavements as you would like on airfields.

Mr. FERRY. Yes.

Mr. NELSON. Has the Air Force tested these types of pavement in the laboratory?

Mr. FERRY. No, sir; we have no laboratory facilities.

Mr. NELSON. So the two types have not been tested in the laboratory?

Mr. FERRY. No. Our conclusions are based upon field experience.

Mr. NELSON. Entirely upon field experience.

Mr. FERRY. Yes.

Mr. HARDY. Mr. Chairman, may I inquire——

Mr. BATES. Mr. Hardy.

Mr. HARDY. You certainly have done a lot of research and development on other things. Are you making no experiments at all in connection with thin runway coating?

Mr. FERRY. We have made some experiments, sir, on runway coatings, but it has not been on a properly organized overall basis. It has been the sort of thing—we have tried a few things here and a few things there. Frankly we have not entered into a long-term engineering testing of these coatings.

Mr. HARDY. Would that necessarily be a long-term proposition?

Mr. HARDY. Woud that necessarily be a long-term proposition?

Mr. FERRY. Yes, sir. Lots of things like that start out very nicely. They look fine for a while. We have found in our—I repeat, from personal experience—that we had some coatings that looked like they would do a job good. They started to crack. Some of the fuel spillage got down underneath. The asphalt pavement beneath it deteriorated bad, because it didn't have a chance to evaporate—the fuel.

Mr. HARDY. Is anybody doing any actual experimentation?

Mr. FERRY. Yes, the Corps of Engineers are doing a great deal of experimenting in the laboratory at Vicksburg. They are our constructing agency. They are making extensive and intelligent approaches to this problem.

Mr. HARDY. Thank you.

Mr. BATES. Mr. Ferry, in view of the principle which you have established, I wonder if you could give us for the record either two or three examples where you had these alternate bids and the cost of them and in view of the comment of Mr. Nelson, I would like to have one of them be Plattsburg.

Mr. FERRY. I will ask, if I may, to have one of my backup gentlemen here who has that information——

Mr. BATES. They can be inserted in the record.

Mr. FERRY. Yes. I shall be pleased to do so.

Mr. NELSON. How did the Air Force arrive at this 5-percent differential, Mr. Ferry?

Mr. FERRY. Our field commanders came in with a flat statement that they believed in their judgment that we would be warranted in paying a premium up to 10 percent and we sat around, some of the people who were responsible for that end of the business, and we said, "We think 10 percent is just too much. It just doesn't seem good judgment." So we arbitrarily—by "arbitrarily," I think I may have been the impelling factor—and we said, "Let's make it 5 percent."

Mr. NELSON. You picked 5 percent?

Mr. FERRY. Right out of the air.

Mr. NELSON. It is not based upon the difference in maintenance costs, not based upon the estimate of longevity, it is just based on your hunch that it is better to pay a 5 percent differential?

Mr. FERRY. Hunch, or let's call it an engineering judgment.

Mr. HARDY. I though engineering judgment is always supported by facts.

Mr. FERRY. No, indeed. Many times the engineer has to pick things off the chandelier because facts are not available.

Mr. HÉBERT. It has been testified that the 5 percent is really 15 to 20 and 25 percent. What would you say to that, Mr. Ferry, in actual cost?

Mr. FERRY. For a small portion of the runway it might be so, sir.

Mr. HÉBERT. That is what Mr. Fisher was asking you, by not separating these bids—the 5 percent figure is really a misleading figure because actually, according to the testimony, as I appreciated it yesterday, it runs 15, 20, and 25 percent.

Mr. FERRY. On a portion of the runway, if you separate it out, it might run 15, 20, or 25 percent on that portion of the runway.

Mr. HÉBERT. That is correct.

Mr. FERRY. That could possibly have been so.

Mr. HÉBERT. By putting it under the same kettle you come out with 5 percent which is in reality not a true picture of the less cost in using asphalt?

Mr. FERRY. It is a question of semantics, I think, sir. We might debate that.

Mr. HÉBERT. I might have a vest on. You want a suit without a vest.

So you come in and tell me. "I want to buy this suit cheaper."

But you can't bid; you can't offer to sell me a suit cheaper. You have to sell me the whole suit. That doesn't mean that the vest is only 5 percent. It may be 25 percent.

Mr. FERRY. We took a 5 percent differential on the pavement bids overall. That is what I meant when I said it was a question of semantics.

Mr. HÉBERT. It still doesn't give the true picture. The asphalt people have a product to sell. I am just trying to find out in dollars, Where does the Government come out? That is all I am interested in. What is the cheaper thing when all factors are taken into consideration. Are these bids and qualifications going to be "rigged"—I use the word "rigged" in quotes, not to show any intention on the part of the Air Force, if they are being rigged to the exclusion of the asphalt people, under the guise that it is a 5-percent differential when in reality it is a 15- and 20- and 25-percent differential. I think we should know about it.

Mr. FERRY. I would like to clarify your word "rigged" there. I do not think you meant it in any sense of rigging and I would like to assure the committee that the Air Force in asking for these comparable bids does not intend nor does it rig the bids——

Mr. HÉBERT. I said I would quote "rig" just to show an indication of what I am talking about. I didn't mean any indication. It comes out in the ultimate that it costs more money.

Mr. FERRY. Yes, sir. We admit it costs 5 percent more money.

Mr. HÉBERT. Five percent when you consider the whole suit of clothes.

Mr. FERRY. That is what we are buying—a whole suit of clothes.

Mr. HÉBERT. These fellows that are selling the funny waistcoats couldn't compete—they might be out of business.

Mr. FERRY. It might be a good thing, sir.

Mr. NELSON. What he means is that the 5 percent should include not only the suit, vest, but the hat, shoes, the sock, and the underclothes.

Mr. FERRY. Well, we might carry that even——

Mr. HÉBERT. As is indicated, what was done at Plattsburg.

Mr. FERRY. I reserve comment on Plattsburg through unfamiliarity.

Mr. BATES. Will you proceed with reading the statement of the field commanders, Mr. Ferry?

Mr. FERRY. Yes.

These are extracts, are not complete statements of the commanders—in the interest of purely of simplifying the hearings.

This is from Lt. Gen. Robert Harper:

It is my opinion that the construction of asphalt pavements, particularly at jet aircraft bases, is false economy.

Gen. Curtis E. LeMay, commander, SAC.

The requirement * * * to either prove damage before it occurs or take an inferior product is a novel approach to economy and good buying * * * We have protested new asphaltic construction consistently.

Brig. Gen. C. J. Bondley, Jr., D/Materiel, Headquarters SAC.

Pavement damage reports, covering operations at 12 SAC bases during the period January to June 1953, indicate that damage to nonrigid pavements was directly attributable to jet operations * * * jet blast and fuel spillage. * * *

Headquarters, USAFE:

Asphaltic type pavements on several fields in the United Kingdom have required extensive maintenance and/or replacement because of damage from spilled fuels.

Mr. NELSON. Will you read LeMay's statement again, please?

Mr. FERRY. Yes [reading]:

The requirement * * * to either prove damage before it occurs or take an inferior product is a novel approach to economy and good buying. * * * We have protested new asphaltic construction consistently.

Mr. NELSON. Don't you think, Mr. Ferry, that you have to prove damage before it occurs to prove that it is an inferior product?

Mr. FERRY. Legally, sir, you are quite correct, but I think if you were to go out and buy a coat of paint for your house, you wouldn't buy the cheapest paint that you could put on that house because you know it wouldn't stand up.

Mr. NELSON. I certainly wouldn't, but in that particular instance we have vast experience in use of those various types of pavement to prove that that paint is inferior and what I point out is that you have admitted that you haven't enough actual experience to reach a sound conclusion, that it is your engineering judgment.

Mr. FERRY. That is correct.

Mr. HARDY. Do you construe the statement of General LeMay to mean that he doesn't want any asphalt paving in any field?

Mr. FERRY. That is correct. That is what I construe it to be.

Mr. BATES. Do you agree with that statement?

Mr. FERRY. It depends on price, sir. If it was a tremendous differential you couldn't justify the thing economically.

Mr. BATES. You are not asking the committee to accept his statement at face value?

Mr. FERRY. I am quoting responsible commanders' attitudes on the use of asphalt paving.

Mr. BATES. But as an engineer you would modify that statement?

Mr. FERRY. To the extent that everything has a value commensurate with its first cost and ultimate cost and one must weigh both first cost and ultimate cost in comparison to the advantages offered by one product.

Mr. BATES. Because that statement is somewhat at variance with the criteria you have established earlier.

Mr. FERRY. I do not see the inconsistencies, Mr. Bates. You weigh it. You weigh it and evaluate it from the best knowledge that is available to you, that based upon current practice, based upon past experience and based upon what you look to the future for.

Mr. BATES. In answer to the inquiry of Mr. Hardy, you said that the intent in that letter was just to take the concrete and that was it?

Mr. HÉBERT. That is the same thing that gives the Air Force Buicks and the other services Chevrolets.

Mr. BATES. Mr. Nelson.

Mr. NELSON. Does the Air Force have any evidence in its files or in its experience of blast damage, of damage by fuel spillage to concrete?

Mr. FERRY. No, sir. To the filler. I want to qualify that. To the joint filler; in between the concrete slabs we have some cases where it was defective and it was broken out and had to be replaced. To the concrete itself, no.

Mr. NELSON. How many all-concrete runways operating jets does the Air Force have?

Mr. FERRY. Very few, sir. I cannot answer. Several dozen, sir, I am told.

Mr. HARDY. May I ask a question:

Is there any experience to indicate any appreciable variation in maintenance cost of a runway as against asphalt and concrete?

Mr. FERRY. If you ask in dollars to evaluate it by particular bases I cannot furnish the information.

Mr. HARDY. All you have is some horseback figure?

Mr. FERRY. No, better than that. We have evidence of inspection that damage has occurred in short periods of time with asphaltic pavement whereas no damage has occurred to similar locations of concrete.

Mr. HARDY. I think we should have some indication as to the extent of that damage that is referred to beyond the concrete portion of the runway.

Mr. NELSON. I think we should have the evidence and in specific cases.

Mr. FERRY. We will be glad to produce that.

Mr. BATES. The committee will stand in recess until 2 o'clock this afternoon.

Mr. FERRY. May I be excused, sir, due to another engagement?

Mr. BATES. Yes, you may be excused, Mr. Ferry. We are through with you.

(Thereupon, at 11:55 a. m., the committee recessed until 2 p. m.)

AFTERNOON SESSION

(The committee convened at 2 p.m.)

Mr. HESS. Are we all ready?

Mr. COURTNEY. All right, Mr. Chairman.

Mr. HESS. The committee will come to order.

Mr. COURTNEY. We have General Ramey.

TESTIMONY OF GEN. R. M. RAMEY, DIRECTOR OF OPERATIONS, AIR FORCE

General RAMEY. I am R. M. Ramey, Director of Operations for the Air Force. I am not an engineer, Mr. Chairman. I have been asked to testify from an operational standpoint, that operational delays in training and in actual combat operations have resulted from the fact that high angle of incidence, slow moving maximum temperature jet blasts, deteriorates runways, as well as spillage of hydrocarbon fuel on asphaltic concrete runways, generally at the end of the runways, but some evidence of the same effect throughout the runways.

This same jet blast and spillage also deteriorates parking aprons, refueling aprons, warmup pads, and so forth.

We have had continual complaints of these matters from our commanders, probably lacking somewhat in complete data because commanders are prone to report difficulty from this and not always submit a complete report of what has happened.

There are other disadvantages that we experience from an operational standpoint. Asphalt runways will burn in event of a crash. There are some very minor advantages of concrete, which probably are increased visibility at times when visibility is poor at night and in bad weather.

In general, we have experienced delay throughout the training command on, most of all, of SAC bases.

We had a very good example of a runway that we operated in K–2, in Korea, which we operated for 9 months as an asphalt runway and then put concrete over the runway and were able to increase operations over about a 5-month period by about 25 percent as a result of no delays for continual repairs, shoveling out and removing the loose gravel aggregate at that had been caused by the spillage of fuel and by jet blasts on these runways.

Mr. HESS. What effect does the spillage of fuel have on the asphalt, General?

General RAMEY. It seems to completely destroy the binding quality.

Mr. HESS. Does the surface disintegrate, then?

General RAMEY. The surface disintegrates and you just got a pile of loose gravel there.

The main disadvantage of this graveling effect is that the jet engines suck up stones that go inside the engine and tear up the blades, which can just ruin an engine or can cause an accident. It can cause serious skin damage when throw against the skin of the airplane, which under stress at very high speeds might rip further.

Mr. HESS. What type of construction do you have at your airbase in Newfoundland, at Thule?

General RAMEY. Those are concrete, sir.

Mr. HESS. All concrete runways, are they?

General RAMEY. Yes, sir.

Mr. HESS. Solid concrete?

General RAMEY. Yes, sir.

Mr. HESS. Any questions, Mr. Nelson?

Mr. NELSON. I have none.

Mr. HESS. Questions?

Mr. FISHER. General, the asphalt people testified here yesterday, I believe, and they indicated that some of the trouble that has resulted from the use of asphalt pavements have been because of faulty construction.

Now, are you in position to know whether the instance you gave in Korea was due to faulty construction, or if the breakage there or the failure of the pavement was a normal thing?

General RAMEY. I haven't at all any knowledge of where the construction there was faulty. I would say there is probably more chance of faulty construction there than there would be other places. However, our experience with deterioration of asphaltic concrete runways has been so general, sir, that I would say the chances of all the places we have had this trouble reported to us, it would not be due to faulty construction.

Mr. FISHER. I see. All right.

Mr. HÉBERT. May I ask one question?

General RAMEY. Yes, sir.

Mr. HÉBERT. General, you indicated the damage to the airplane, the gravel probably going up to the jet opening there.

General RAMEY. Yes.

Mr. HÉBERT. Now, are you addressing yourself to the use of asphalt in critical areas and not in noncritical areas; is that correct, General?

General RAMEY. I tried to make the statement, sir, that the effect of this is much more pronounced in critical areas, so much more that although we haven't gotten the commanders to agree they would accept asphalt in the center parts of these runways, in the middle parts, we have considered and they have admitted the damage there is probably little enough that we could afford to be consistent with cost on that part of the runway.

Mr. HÉBERT. Well, of course——

General RAMEY. They nearly all want concrete.

Mr. FISHER. The question at hand, I think—there is no dispute in what you have said. The asphalt people themselves readily admit that in critical areas the use of concrete is preferable.

General RAMEY. Yes, sir.

Mr. HÉBERT. So that is not in dispute at all.

General RAMEY. This deterioration, sir, is evident throughout the runway, but much less evident in from, say roughly approximating a thousand feet from either end. The commanders can correctly point to places where it is evident in the other parts of the runway.

Now, it would require an extensive analysis by the engineers perhaps and the experience of the commanders as to what accidents they have had caused or what operational difficulty, as to how much that would be worth to make the center part of the runway.

Mr. HÉBERT. Have you any comment or complaint from an operational standpoint or approach to the asphalt in the noncritical areas causing damage?

General RAMEY. Yes, sir. We have had an accident or so that has been attributable to high-pressure tire marks.

Mr. HÉBERT. Where?

General RAMEY. I am thinking particularly of an accident we had at Clovis that was due to high-pressure tire mark in the center of the runway, that perhaps due to the extreme hot climate at the time or the runway not being designed for the short harder tires we use in the modern airplane, they cause ruts.

Mr. HÉBERT. Did that report say it was caused by the use of asphalt?

General RAMEY. It says it was caused by ruts.

Mr. HÉBERT. And the runway was asphalt?

General RAMEY. Yes.

Mr. HÉBERT. Would you let the committee have that report?

General RAMEY. I believe it is available.

Mr. HÉBERT. Any other?

General RAMEY. I don't think of any other at the moment.

Mr. HÉBERT. It is not general, then; it is just one case you know of?

General RAMEY. I would say there are more than one case, sir, although I would have to look through the files to find it out.

Mr. HÉBERT. If there were more, the Air Force would have a record of it, wouldn't they?

General RAMEY. I am sure it is somewhere in the record. I will be glad to look and see.

Mr. HÉBERT. Keep in mind that if you submit only one case, the committee will conclude that there is only one case. If you can't come back and show there are several, we can't assume that.

General RAMEY. I believe it was reported there are several.

Mr. HÉBERT. Of course, human frailty is something in most of us, and we can't accept what we believe we hear. We want the record to show we have it.

General RAMEY. All right, sir.

Mr. HESS. Mr. Courtney.

Mr. COURTNEY. General, was the runway at Clovis designed for jet use?

General RAMEY. No, sir. That was a World War II runway designed for B–17 training, I believe, sir.

Mr. COURTNEY. And would you be able to distinguish in the reports that you will present to the committee where your damage has occurred between asphalt runways which were designed for the old reciprocating engine-type plane as against jet?

General RAMEY. Would you repeat the question, please?

Mr. COURTNEY. Well, in pointing out the damages that you have experienced and have been reported to you, will you distinguish for the committee between those airstrips that were prejet build and operating and those which were designed for use by jets?

(The following was later received for insertion at this point.)

SUMMARY OF PAVEMENT DAMAGE REPORTS (JET FUEL AND BLAST ON ASPHALTIC) (CONCRETE PAVEMENT)—JUNE 10, 1953

Bergstrom	**Hamilton**	**McChord**
Castle	**Laredo**	**Pinecastle**
Craig	**Limestone**	**Scott**
Eglin	**Lockbourne**	**Travis**
Fairchild	**MacDill**	**Turner**
Geiger	**March**	**Williams**

BERGSTROM AIR FORCE BASE

The pavements described were built during World War II and were not equal in quality to present standards. Faulty base construction also contributed to pavement failure.

Report of damage by SAC November 1950; report of damage by SAC February 1952.

1. SAC reported in November 1950 that 2-inch asphaltic concrete surface on the taxiways had disintegrated due to fuel spillage. The asphalt was stripped from the aggregate allowing water to penetrate the surface. It appeared that the fuel spillage was not damaging to the pavement except where the planes warm up, stand still, or slow for turns and then accelerate to pick up speed again. Pavement in question was of poor quality in comparison to present standard hot plant mix. An M. and O. project for $40,000 was approved for rehabilitating the pavement using a high quality asphaltic concrete.

2. SAC reported again in February 1952 that 26,000 square yards asphaltic concrete pavement have been damaged by jet fuel spillage, jet plane operations and by moisture which was penetrating the base of airfield pavements, costing $78,000 for repairs.

CASTLE AIR FORCE BASE

The pavement described herein was constructed during World War II and was of high-quality asphaltic concrete.

1. Report of damage by AIR March 1951

This report notes considerable difficulty in maintaining the existing asphaltic concrete parking area due to fuel spillage causing rapid deterioration. Four years of continuous parking on two areas consisting of rigid and flexible type pavements resulted in no expenditure of funds on the cement concrete area, whereas the asphalt area required continuous local maintenance in addition to a $57,743 repair project.

2. Report of damage by SAC February 1952

It was reported that extensive damage had occurred by jet fuel and engine oil spillage, particularly in working areas. Recommended that new parking aprons be of cement concrete.

3. Report by J. R. Benson, consultant

Existing surface is soft in numerous areas due to aviation gas absorption, but areas are stable and functioning satisfactorily. Great care was being taken to prevent further fuel damage by absorbing spillage with sand thrown over the area and subsequently removing the sand.

CRAIG AIR FORCE BASE

The pavements described herein were constructed during World War II although of good quality they were not of the highest standard.

Damage reported by SAD AFIRO January 23, 1953; investigated by SAD AFIRO January 22, 1953.

Report covered observation of several small areas on old runway being used for parking T–33 aircraft. Damage from spilled fuel limited to areas 4 to 6 feet square where repeated spillage of fuel had softened the old pavement. Type of original construction not indicated but obviously was not high type asphaltic concrete. Report states no damage from blast. However, fuel spillage presently occurring on bituminous pavements will cause complete failure.

EGLIN AIR FORCE BASE

The pavements herein described were constructed during World War II or shortly thereafter. Design and construction was not in accordance with present-day standards.

Damage reported by J. R. Benson, consultant, and L. B. Crowley, AFOAI, February 1952.

1. Report of damage covered observations of taxiways and runways on auxiliary field No. 2. These pavements consist of sand-asphalt with tar seal and subjected to intensive jet operation. It was observed that fuel spillage had little effect on the sand-asphalt but when penetrated through the tar seal it softened the sand-asphalt, in which case the tar seal was of negative value.

2. Observations of the surfaces on fields 6, 3, and main base revealed similar damage.

FAIRCHILD AIR FORCE BASE

Pavements described herein were constructed in 1951 in accordance with design criteria for high-quality dense graded asphaltic concrete.

Report of damage by J. R. Benson, consultant, and L. B. Crowley, AFOAI-M, March 1952.

Observations indicated that spillage of aviation gas had softened several parking and refueling pavement areas. Refueling spillage is severe.

GEIGER AIR FORCE BASE

Pavements described herein are high type asphaltic concrete constructed during during World War II.

Report of damage by OCE, August 1951, and J. R. Benson, consultant, March 1952.

Observations covered by these reports indicate some blast damage to the surface treated shoulders and runway overrun areas. Thin surface treatments on taxiways and runways have been largely destroyed by jet blast.

HAMILTON AIR FORCE BASE

Pavements described herein are high type asphaltic concrete constructed during World War II.

Investigation of damage by J. R. Benson, consultant, March 1952.

Investigation covered observation of all pavements. No damage was found as result of fuel spillage but some eroded blast areas were noted on the runway end. The damage was considered insignificant in area.

LAREDO AIR FORCE BASE

Pavements described were constructed in accordance with current high type asphaltic concrete requirements.

Report of damage by AFIR SWD October 1952, January 1953, and March 1953.

1. Report of investigation in October 1952 covered observation of runway extension. As a result of this inspection it was noted that there was no discernible deterioration of the pavement due to jet fuel spillage.

2. The investigation in January 1953 covered observation of all pavements. It was noted that jet spillage had softened some small areas on the taxiway to a depth of three-quarter inches but was not sufficiently soft to show markings of aircraft tires.

3. The investigation in March 1953 notes no change in the condition of the asphalt pavement due to fuel spillage since the previous inspection. However, it was suggested that damage due to spillage may become more prevalent during the hot months.

LIMESTONE AIR FORCE BASE

Pavements described were constructed in 1947–48 in accordance with current high quality asphaltic concrete design requirements.

Report of damage by ADC July 1952.

1. Investigation by C. M. Bennett, paving engineer, covered observations of damage to ramp and runway. Melting of the asphalt seal coat on the ramp over an area of 4 by 20 feet occurred when jet engines were run up to start taxiing to runway.

2. Two F–89C jet aircraft were observed in take-off from the south end of runway. Heat caused the asphalt to melt and blast back over an area of 6 by 50 feet to depth of one-quarter inch.

3. A subsequent report by E. M. Howard, Asphalt Institute, in August 1952, notes that minor scouring of four small areas on edge of taxiways where jets had been "revving up" occurred. Also, a small area of seal on the apron was damaged, but the pavement was otherwise in good condition.

LOCKBOURNE AIR FORCE BASE

Pavements described are high quality asphaltic concrete constructed after World War II.

Damage reported by J. R. Benson, consultant, and L. B. Crowley AFOAI–M February 1952.

1. Report of investigation covered observation of the portions of aprons with asphaltic concrete overlay which had been subject to fuel spillage. Examination

of the pavement indicated that most of the areas were now normal, except that a few areas recently subjected to spillage had softened to a depth of one-quarter inch, especially when a seal had been applied.

2. Observations also covered the southwest end of the northeast-southwest runway where the blast effect had softened and blown back the seal over the asphaltic concrete overlay.

MAC DILL AIR FORCE BASE

Apron pavements were constructed in accordance with present design requirements for high quality asphaltic concrete. Runway pavements were constructed of high quality asphaltic concrete during World War II.

1. Damage reported by AFIR, SAD

Investigated by J. R. Benson, consultant February 13, 1952.

Report of investigation covered observations on apron and runway. Areas on apron softened by repetitive parking of B-47's, but are not excessively soft beyond occasional tire mark. Two areas on runway revealed erosion of seal coat but no damage to pavement. One blast area eroded pavement to five-sixteenths inch depth after extended run-up.

2. Damage reported by SAC April 27, 1952

Investigation by resident engineer OCE May 16, 1952.

New apron softened by fuel, oil and solvents. Some areas remained soft 3 to 4 weeks after spillage. No permanent damage unless material is displaced. Blast damage occurred in one area of apron during B-47 run-up, 1 to 1½ inches deep.

3. Investigation by SAD OCE and AFIR January 8, 1953

Report covered observations on runway taxiway and aprons. Of the total 665,000 square yards of new pavement only a few scuffed areas were noted. These occurred in early life of the pavement. No repairs have been accomplished and none required. Excellent condition of pavement attributed to good housekeeping.

4. Report by Lieutenant Colonel Clifford June 16, 1953

No damage was evident on asphaltic concrete aprons but was prevented by use of cans to catch drippage or the pavement flushed with fire extinguisher to spread fuel spilled.

MARCH AIR FORCE BASE

Pavements constructed in 1951 in accordance with current design for high quality asphaltic concrete airfield pavement.

Report of damage by Mr. J. B. Benson and Mr. L. B. Crowley, March 1952.

It was noted that new asphaltic concrete runway, taxiway and apron pavements had just been completed. In the areas subjected to the fuel absorption text, softening of the surface was almost instantaneous.

M'CHORD AIR FORCE BASE

Pavements described are of high quality asphaltic concrete constructed in 1951.

Damage reported by J. R. Benson, consultant, and L. B. Crowley, AFOAI-M March 1952.

1. Damage reported by AFIR June 27, 1951

Damage was observed to the taxiway pavement by a Navy jet plane. Area of asphalt surface about size of office desk was soft 8 days after spillage. This was on new specially controlled asphalt surface.

2. Report of investigation covered observations of the apron area used for parking and refueling. Several areas had absorbed fuel and softened but without cutting. A seal had been placed at some previous time but did not prevent fuel absorption and may have hindered evaporation.

PINECASTLE AIR FORCE BASE

1. Damage reported by J. R. Benson, consultant, February 15, 1952

A large area of asphaltic concrete pavement had just been completed and jet plane operations had not been initiated. However, a test section treated with kerosene was observed and found to be quite soft. It was believed that ruffing or displacement would have occurred under a rolling wheel load.

2. Observations by General Burns, December 1952

There was evidence of considerable damage on the apron resulting from jet fuel spillage.

3. Report covered observations on runway taxiways and apron. Pavements have been utilized since April 1952 by T–33, F–80, F–84 and B–47 aircraft. No damage occurred on runway, taxiways or warm-up pad although there has been considerable spillage at hold point on warm-up pad, but without softening or displacement. There was slight deterioration by fuel spillage on the apron area utilized by F–84 and transient aircraft. The area of apron for parking F–80 was rapidly deteriorating by excessive daily spillage—an approximately 20-foot diameter area under each aircraft. Softening has occurred in several of these areas to total depth of 4 inches and replacement in some areas approximately 1½ inches in depth. Considerable repair to the apron recommended a necessity.

4. Damage reported by Lieutenant Colonel Clifford, June 16, 1953

The asphaltic concrete parking aprons show damage due to fuel spillage and blast. There are wet spots of varying extent under practically all engines, some of which show softening to the depth of the pavement and some of the bitumen has been washed out of the pavement.

SCOTT AIR FORCE BASE

Pavements were constructed in 1953 in accordance with current requirements for asphaltic concrete airfield pavement.

1. Report of damage by Mr. A. S. Wellborn, Asphalt Institute, September 22, 1953

It was observed that the asphalt pavement on the whole was in good condition. There was some damage on apron areas where F86's had been parked and serviced. It is noted that no one could expect a plain asphalt pavement to indefinitely withstand the abuse to which this particular pavement is subjected.

2. Report of damage by Lt. Col. L. B. Scott, Inspector General Headquarters 33d Air Division, September 15, 1953

Damage to parking ramp in front of maintenance hangar from fuel spillage is serious problem. The use of buckets to catch the spilled fuel is unsatisfactory due to frequent high winds and jet blast. Condition of the parking area after less than a month of limited operation is considered to be highly unsatisfactory. Recommends early application of jet fuel resistant sealing compound and if deterioration continues to occur, that consideration be given to overlay of cement concrete.

TRAVIS AIR FORCE BASE

Apron pavements were constructed 1951–52 in accordance with highway pavement standards. Though high quality asphaltic concrete they do not meet present design requirements for airfield pavement. Runway pavement was constructed during World War II.

1. Damage reported by AFIR SPD December 1951; investigated by DE OCE SPD March 1, 1952

Report of investigation covered observation of light duty pavement around concrete HB hardstands. The AFIR reported damage to 110,000 square yards. The district engineer investigational report estimated damage to approximately 300 square yards by fuel spillage and 100 square yards from drippings by reciprocating engines. The pavement is a vehicle type pavement and not designed to standard high type specifications and could not be expected to resist continuous fuel and oil spillage.

2. Report by SAC February 25, 1952

Damage to approximately 20,000 square yards of asphaltic concrete hardstands cost over $79,000 in reparations, all due to fuel spillage.

TURNER AIR FORCE BASE

Pavements described were constructed in accordance with current airfield pavement standards.

Damage reported by SAD AFIRO January 17, 1953; investigated by SAD AFIRO January 7, 1953.

Report covered observations on runways and taxiways only, the parking apron being concrete. After 1 year's operation by F–84 aircraft 3 skin patches had

been made, a total of 3 square yards in area, resulting from fuel spillage. Two areas of about 8 square yards each had been burned by a transient B–45 but had not been patched. No additional maintenance was recommended.

WILLIAMS AIR FORCE BASE

Pavement designed in accordance with current high-type asphaltic concrete design requirements for airfield pavements. Although meeting design requirements for stability the void limit was exceeded resulting in a relatively porous structure permitting absorption of spilled fuel.

Report of damage by Mr. J. R. Benson and Mr. L. B. Crowley March 1952.

A large area of apron pavement completed the previous year had not been used due to a high susceptibility of the pavement to fuel damage. The pavement areas subjected to fuel spillage softened and lost cohesiveness almost immediately. The apron pavement is not suitable for parking or servicing jet planes.

General RAMEY. I am not an engineer enough to tell you whether or not there is any difference in asphalt construction on runways designed for jets and runways not designed for jets. I am of the opinion that the majority of reports that we have here—I have listed here maybe a dozen or more—fields that we have had trouble on, were all fields built before the jet era.

Mr. COURTNEY. Yes. You are going to make that distinction or at least have someone in an engineering capacity make that distinction, so the committee can evaluate the report?

General RAMEY. If there is a difference?

Mr. COURTNEY. Yes, sir.

General RAMEY. I presume the engineers can tell you that, sir. I can't.

Mr. COURTNEY. Now, do you know of a field where the Air Force has built an airstrip of asphalt, either in whole or in part, which was distinctly designed for jet use?

General RAMEY. Well, we built fields—the asphalt fields that we used in Korea, of course, to use jets on. Now, whether or not—I don't believe, to my knowledge, there is no difference in designing a field for jet use, if you had to use asphalt, than there would be for any other use.

Mr. COURTNEY. Well, I mean the structural design, depth and density of the materials used. Make the assumption that there is a difference. Or if there is not any difference, then point that out to us, will you, when you present your report on damages?

General RAMEY. I am not exactly clear as to that.

Mr. COURTNEY. Well, we want to be able to distinguish in your report the cases where damage has occurred on prejet fields, to call them by the right name, or where the design was of the same standard as the prejet field.

General RAMEY. Do you want a report of the accidents that have occurred on asphalt fields?

Mr. COURTNEY. On asphalt fields, distinguished between those that occurred prejet design and those that have occurred on fields that you say in your own engineering opinion were designed directly and distinctly and purposely for the use of jets. You understand?

General RAMEY. Yes, I understand this is an initial request for a report of accidents that have occurred on asphalt fields?

Mr. COURTNEY. Damage.

General RAMEY. Yes, sir.

Mr. COURTNEY. That is all. (The following was later received for insertion at this point.)

The following is a list of aircraft accidents which were attributed solely to impaired asphalt runways during calendar years 1952 and 1953. This impairment was in all cases reported to have been caused by heat blast and fuel spillage resulting from continued use by jet aircraft. There have been other accidents reported in which runway conditions of asphalt runways have been contributing but not sole cause.

Type	Place	Accident	Damage
F-80C	Suwon	Heat softened surface caused airplane to skid on landing	Substantial.
F-94B	do	Bounced on rough asphalt into asphalt lip under repair	Do.
F-86C	Kimpo	Rough asphalt blew tire on landing	Do.
F-84G	Kisarazu	Heat softened asphalt ruts caused loss of directional control	Destroyed.
F-80C	Yontan	Rough runway prevented adequate braking action after aborted takeoff. Required gear retract.	Substantial.
F-86E	Kimpo	Ground roughing due to asphalt ruts	Minor.
F-80C	Yontan	Rough asphalt ruts caused loss of control	Substantial.
F-84G	Kunsan	Gear collapsed on runway softened by jet planes	Minor.
F-86E	Kisarazu	Aircraft struck hole in runway	Do.
F-84G	Dow	Aircraft struck loose gravel and macadam on shoulder	Destroyed.
F-86F	do	Aircraft struck loose gravel on shoulder	Do.
F-61H	Grenier	Heat softened taxiway collapsed under left gear	Substantial.

The fields involved in these accidents were both pre- and post-jet operation construction. Dow, Grenier, Yontan, and Kisarazu were World War II fields rehabilitated; while Kimpo, Suwon, and Kunsan were constructed for jet operations.

Mr. HESS. Any questions?

Mr. NELSON. Yes.

General, that would be where the cause of the damage was attributable, directly attributable to the fault of the field?

General RAMEY. Yes, sir. As I understand, that is what the gentleman wants.

Mr. COURTNEY. Yes.

Mr. HÉBERT. That is correct, which is caused by asphalt. I don't care what else it was caused by. We are only interested in accidents caused by asphalt. And Mr. Courtney has indicated whether it was on a prejet field or a jet constructed field.

General RAMEY. I would say in general they will all be prejet fields, with the exception of Korea.

Mr. COURTNEY. Korea.

General RAMEY. There may be some that we have built since.

Mr. HÉBERT. We have only one known accident now, so we are not in the plural stage yet of "they."

Mr. NELSON. These fields that you mentioned, General, have they all been reconstructed or are they in the same condition they were in World War II?

General RAMEY. They have all had repairs done to them, sir. We are operating from them now, the fields that I am talking about in general.

Mr. NELSON. General, you indicated to this committee that the jet plane gets no gravel or rocks, or anything of that kind, with concrete?

General RAMEY. If they are properly kept clean, they wouldn't, no, sir.

Mr. NELSON. Well, are they all properly kept clean?

General RAMEY. There is an attempt made to keep them clean. They are swept, yes, sir.

Mr. NELSON. For instance, in the desert area, where you get sandstone and all that stuff.

General RAMEY. Yes, sir. We can get rocks from any field that isn't kept clean.

Mr. COURTNEY. You can keep an asphalt pavement clean, can't you?

General RAMEY. No, sir. With this loose aggregate, the only way you could keep it clean is by sweeping the asphalt off.

Mr. COURTNEY. Well, if your concrete spalls for any reason whatsoever, your concrete is the same, isn't it?

General RAMEY. Yes, sir.

Mr. NELSON. Where do you get this loose aggregate from?

General RAMEY. It is what remains after the binding element is destroyed by this heat and fuel, sir.

Mr. NELSON. You get that from spillage?

General RAMEY. Some from spillage and some from heat, yes, sir.

Mr. NELSON. Well, now, tell the committee, will you, General, where you get the most of this from spillage and from heat? Where do you get it?

General RAMEY. Yes, sir. I tried to explain it. By far, the greater part of it is on the ends of the runways, on the parking and fueling aprons and on the warmup pads.

Mr. HESS. That is all concrete, though, isn't it?

General RAMEY. I am talking about where there is no concrete, sir, on the asphaltic concrete.

Mr. NELSON. So you get no loose aggregate on the runways with asphalt?

General RAMEY. There is some evidence of deterioration the commanders have reported on runways; yes, sir.

Mr. NELSON. General, is the testimony you are giving the committee today based upon the reports you have had from field commanders or from actual observation?

General RAMEY. It is based on both, sir.

Mr. NELSON. Could you tell the committee about the deterioration of runways that you yourself have seen and where they were?

General RAMEY. Yes, sir. I have inspected a great many runways. One of the worst condition of asphalt runways I have seen was at the school at Williams. Another was at Bergstrom runway in Austin. I have seen the runway at Clovis. I have seen the runway at Travis. I have seen the runway at Pine Castle, at Gieger, at Eglin, at Fairchild, at Castle. I believe I have seen most of them. I have gotten reports over a period of 3½ years of various delays and damages due to jet.

Mr. NELSON. Would you tell us what the condition of those runways was that you have enumerated? I assume from your testimony these are all World War II fields?

General RAMEY. These are all World War II fields; yes, sir.

The runway at Williams and the runway at Bergstrom finally became unusable. We had to stop operations until we could repair them. Most of the other runways that I can remember here have been runways that we repaired probably in odd hours and didn't completely stop operations.

Those are the only two fields that I can testify right now that we stopped operations on while we repaired them.

Mr. NELSON. Were these all fields that had been reconstructed after World War II or were some of them fields that had been reconstructed after World War II or were some of them fields that you are still using the same runways you used in World War II.

General RAMEY. I am unable to answer that, sir, except to say that they probably all had had some maintenance done on them and possibly some were new runways that had been constructed.

Mr. NELSON. Well, where was the damage to the runways?

General RAMEY. Where was the damage to the runway?

Mr. NELSON. Yes.

General RAMEY. The majority of the damage to the runway was on the ends of the runway, approximately the length of a thousand feet, with some damage to the runways, the middle part of the runways, generally near the center of the runway as far as width is concerned, because probably that is where most of the traffic is.

Mr. NELSON. What did you attribute that to?

General RAMEY. Heat, sir, and occasional fuel spillage, although both heat and spillage is less there. And the angle of incidence is not the same there, nor is the speed as slow. In other words, it is exposed to it less times.

Mr. FISHER. Mr. Chairman, may I ask one question?

Mr. HESS. Yes, Mr. Fisher.

Mr. FISHER. General, you were here this morning and heard the Navy discuss this understanding of the so-called critical area as they view it on these fields.

And they consider, according to the testimony, that 500 feet at either end of the runway was critical from their viewpoint.

Now I understand the Air Force feels that it is more than 500 feet at either end.

General RAMEY. The Air Force feels it is a thousand feet at either end.

Mr. FISHER. 1,000 feet?

General RAMEY. Yes, sir.

Mr. FISHER. Will you elaborate on that, just why you set it at a thousand and the Navy seems to think 500 is enough? Is it somewhere in between those 2, or just how firm is that figure of 1,000?

General RAMEY. I doubt if you could say, sir, that it had to be a thousand instead of 995 or 1,100 except that the damage increases as you near the end of the runway. And we received enough damage up to approximately a thousand feet that it seemed worthwhile to us to construct it in concrete instead of continually maintain it.

Mr. FISHER. In other words, your judgment there is based on a study of damages actually done on other fields?

General RAMEY. That is right; yes, sir.

Mr. FISHER. And you came up with a thousand feet as an approximation of the area where there is more likely to be damage?

General RAMEY. That is right; yes, sir.

Mr. COURTNEY. The Navy uses a different type of plane on its field than you do; isn't that right?

General RAMEY. In general; yes. I would hesitate to say that would continue to be true. However, in general, I would say the Navy planes are built to use shorter runways than our airplanes are.

Mr. COURTNEY. And that would account for the difference in the 500 feet and the 1,000 feet?

General RAMEY. That might account for it; yes, sir.

Mr. COURTNEY. And it is also true that the Air Force gives its fields a great deal more use than the average Navy field does; isn't that right?

General RAMEY. Certainly with——

Mr. COURTNEY. Excepting for training fields.

General RAMEY. Type airplanes; yes, sir, that is right.

Mr. HESS. Any more questions of the general?

(No response.)

Mr. HESS. All right.

Mr. COURTNEY. General, thank you very much.

Mr. HESS. Thank you very much, General.

TESTIMONY OF MAJ. GEN. L. B. WASHBOURNE, DIRECTOR OF INSTALLATIONS, AIR FORCE

Mr. COURTNEY. General Washbourne.

General, do you have a prepared statement?

General WASHBOURNE. No, I don't.

Mr. COURTNEY. Identify yourself for the record, General.

General WASHBOURNE. I am Maj. Gen. L. B. Washbourne, director of installations at Headquarters Air Force, here in the Pentagon. As director of installations, I believe you would say that I am equivalent to the chief engineer of the Air Force and it would be my natural duty to develop and promulgate the engineering criteria under which the Air Force facilities are built, either by ourselves or by the construction agencies.

Mr. COURTNEY. Now the most recent of those is the one of January 8, 1954?

General WASHBOURNE. That is correct.

Mr. COURTNEY. Which has been spoken of here in the record, with which you are familiar.

General WASHBOURNE. I haven't heard it spoken, but I did issue a criteria letter to the construction agencies on that date.

Mr. COURTNEY. I am sorry. I think probably you weren't here when we introduced that, and the preceding criteria.

Mr. HESS. That was yesterday, I believe, and the General wasn't here then.

Mr. COURTNEY. I don't believe he was.

Now, General, with respect to the subject of damage, are you able to tell the committee the basis for the statement that damage occurs to planes and to asphalt runways—planes on asphalt runways, jet planes, and asphalt runways themselves, by reason of their use by jets and what your conclusions are as a result of your examination and your studies and your information?

General WASHBOURNE. I trust you don't limit the statement to runways alone, or did you——

Mr. COURTNEY. No.

General WASHBOURNE. Or did you definitely intend to do that?

Mr. COURTNEY. No.

Make a comprehensive answer, will you?

General WASHBOURNE. I think General Ramey made the proper point there, that the damage of the runways and taxiways is less under jet operations than on other types or functions of Air Force pavement.

I think that is accepted by everybody who is close to the problem, that the damage is less on the traffic areas than it is on the nontraffic areas.

But there is a mounting evidence that as we get into jet operations, damage and the cost of it and the interefence with operations is increasing and probably will continue to increase.

We have been studying this proposition, oh, I guess for 12 years. Back in 1942 the Army engineers began a study of pavements for airfields and spent a good deal of money in those investigations. The Air Corps participated while it was still a branch of the Army, and after 1947, when we began our own budgets, we contributed money to those investigations.

I would hazard the guess that we probably put better than $5 million into that investigation since 1948. And those studies are continuing.

Mr. COURTNEY. Of course, those studies would not relate to the use of fields by jet planes, which were not generally in operation——

General WASHBOURNE. Prior to 1950 they did not, but they always were made with a view that some day they would. Because as early as 1943 the German Air Force introduced jets and we could see what was coming. We still can.

Mr. HESS. General, can you briefly give us a picture of what those investigations have shown, whether or not they have brought about a different type of construction and the types of materials that are used and so forth and so on?

General WASHBOURNE. The conclusion we draw is that asphaltic pavements are damaged from jet operations to some degree from three ways: The heat of the jet blast; the blast itself—that is the turbulence element—and the spillage of fuel.

Mr. HESS. Now, you say asphalt pavements.

General WASHBOURNE. Yes.

Mr. HESS. Now, are there different types, or do you just——

General WASHBOURNE. I am not aware of any different types, Mr. Chairman. There is a vast difference in quality of asphalt pavements and that is exactly the nature of our problem.

Mr. HESS. Now, does it affect each one of them in the same way?

General WASHBOURNE. Yes, in the same way, but the matter of degree is the point.

Now, there are instances of asphalt pavements that have shown very little damage to these sources. There are many other places where this damage has been rather immediate and rather apparent and in some cases very extensive.

That is the nature of our problem, to determine from what we have gathered in the last 2 or maybe even 3 years of pretty heavy jet operations what kind of problem we are going to be up against in say 5 or 10 years from now when we reached the all-jet stage.

Mr. HESS. Do you find any damage at all done to concrete pavement either from gasoline or from fuel, rather, or from blast damage?

General WASHBOURNE. No, sir.

No, there is no damage done to concrete from either of those three reasons. Jet propulsion doesn't damage concrete. Other things do. You frequently get a little confusion there. But the jet operations do not damage concrete pavement.

Mr. HESS. What about the fuel, with acids in it?

General WASHBOURNE. I haven't heard of any cases of that happening. I can't say there were none.

It has been mentioned here that the joint filler is subject to that same type of damage that any bitumal is to a degree, but that is not a very expensive or bothersome problem up to now.

Mr. COURTNEY. General, has the Air Force for experimental or other purposes ever specifically designed, taking into account all the improvements that may have been made in the art, a runway strip of asphaltic material, flexible material, purposely for the use of jets?

General WASHBOURNE. The Air Force rarely does any of its own design work on pavement, Mr. Chairman. But we expect that our construction agencies who do this design work are doing it with an eye to jet operations. So far as I know they are. And I was surprised a while ago to hear your reference made to asphalt pavement that was designed for jets as being different from that not designed for jets. That is the first time I knew there was a difference.

Mr. COURTNEY. Well, I perhaps was making an assumption. But if I made the assumption, you would have to correct me. Otherwise, it would be true.

General WASHBOURNE. From our standpoint, there isn't any difference at all in an asphalt pavement designed for jet operations.

Mr. COURTNEY. Well——

General WASHBOURNE. As differentiated from one not so designed.

Mr. COURTNEY. Well, General, isn't there a distinction between the density or the depth, if you please, and the quantities used pre-jet as distinguished from what you would require now for the heavy thrusts?

General WASHBOURNE. Well, there is a good deal of difference in the character of pavement now from say 5 years ago, but it is not due to the jet engine particularly. The weight and performance characteristics of our advancing aircraft is the basic reason why we have insisted on improved quality of pavements of both types.

Mr. HESS. There has been an improvement in both concrete and in asphalt over a period of years, hasn't there?

General WASHBOURNE. Oh, yes. I think that is true, I believe both the asphalt and the concrete interests recognize there is competition there and they have to keep pretty busy in keeping up with advances in aircraft.

Mr. COURTNEY. But the art has been and is increasing in both concrete and asphalt?

General WASHBOURNE. I think so, yes.

Mr. COURTNEY. General, General Ramey spoke of a number of fields where he said he had received reports of damage to planes and to pavement by reason of the three things that you have spoken of—blast and spillage and so on.

Isn't it a fact that nearly all of those fields were the pre-1950 fields and World War II fields? You heard them mentioned?

General WASHBOURNE. So far as I know, every name that General Ramey mentioned, with the exception of Pinecastle, existed prior to Korea.

Mr. COURTNEY. Prior to Korea?

General WASHBOURNE. Yes, I think that is right.

Mr. COURTNEY. Now, General, with respect to the field that was set up in Korea, this K–2: That was more or less of a temporary job, was it not, rather hastily done?

General WASHBOURNE. Mr. Chairman, I am not familiar with K–2 operation at all. I haven't been to Korea since 1947. I just don't know about that.

Mr. COURTNEY. I thought you were familiar with it.

Now, General, don't you consider that price, where you have such heavy demands on you for all the requirements of an expanding aircraft, changes in deployment and the like—don't you think the element of price is an important consideration in determining what material you will use?

General WASHBOURNE. I certainly do.

Mr. COURTNEY. And do you consider that your requirements should be so inflexible that you would have to adhere rigidly to a standard, an arbitrary standard of a 5 percent differential in favor of concrete?

General WASHBOURNE. Well, the 5 percent differential that you mentioned—and I presume you refer to my January 8 directive.

Mr. COURTNEY. That is correct.

General WASHBOURNE. Is scarsely arbitrary. That represents a considered opinion of a great number of people who have faced up to this problem.

My problem is something like this, Mr. Chairman.

We've got to build, or including what we have built, nearly 50 million yards of pavement, since we began the buildup of the Air Force back in 1949. And that represents a very substantial amount of money. And that is the pavement that we are going to have to fly on for our lifetimes, at least a generation.

Knowing that it costs so much money and knowing that we aren't going to be able to take up and re-lay them new every year, whenever we are dissatisfied with them, we have studied this problem pretty thoroughly as to what the requirement has to be. And the magnitude of that investment is what concerns us.

We know that you couldn't possibly replace that pavement for us in terms of ordinary Air Force operations. But during this build-up period, the Government has been willing to furnish that type of investment.

And our concern, frankly, is to try to get together enough judgment, perhaps educated guesses, as was mentioned this morning, so we don't waste our money.

There is a risk in the use of asphalt that has already manifested itself. We can't tell now how bad it is going to be or whether we will find a cure for it. And we are very reluctant to take the risk in that situation.

Mr. COURTNEY. You are not overlooking possible cures, are you?

General WASHBOURNE. Oh, not at all. As a matter of fact, the Air Force has invested a great deal of its engineering and pavement money in the solution of this problem.

As I said we put around, over $5 million into the problem since 1948 and we are continuing to share these laboratory and field test costs with the Corps of Engineers.

Mr. HESS. A saving of $22 million on 22 airfields is quite a sizable saving, wouldn't you say so, General?

General WASHBOURNE. Well, it would be, Mr. Chairman. But I don't believe I could underwrite your figure on that.

Mr. HESS. Well, there were some figures presented here by the asphalt people yesterday showing that by the use of asphalt over concrete for the noncritical areas, there would be a saving of $22 million on bids that were given on these various airfields, 22 airfields.

General WASHBOURNE. Well, I couldn't speak as to those. But generally the figure of $1 million per field is definitely not involved in the execution of this criteria.

And as Mr. Ferry said this morning, that is "the pavement project" that is advertised by the contracting officer.

We particularly defined what a pavement project was, because obviously if you advertise a small section of a job you get one set of conditions and if you advertise it in a different grouping you get others.

We feel that the overall percentage of having a concrete job was at least worth the 5 percent premium. And we may come to you in a few months or a year or two and tell you we think it is more or even less, depending upon the results of our studies and experiments.

Mr. HESS. Is that 5 percent based on just one portion of the contract or the entire contract for the field?

General WASHBOURNE. That is the entire pavement project as it is grouped and advertised by the contracting officer.

Mr. HESS. It includes both the critical and noncritical areas, then?

General WASHBOURNE. Oh, yes, and the drainage and all the other stuff that goes to make up the pavement project.

Mr. HESS. Is that fair, to have a five percent differential on the entire cost, when you know you are not going to have alternate bids on the critical areas?

General WASHBOURNE. Yes, sir. We think that it is quite fair, because the way the contractors have to mobilize and figure a big job.

Mr. HESS. It is possible that there may be a 25 or 30 percent differential between concrete and asphalt on the noncritical areas.

General WASHBOURNE. It is possible——

Mr. HESS. But still it would be less than 5 percent on the overall cost.

General WASHBOURNE. That is correct, yes, sir. That is exactly the position we find ourselves in.

Mr. COURTNEY. Now you spoke——

General WASHBOURNE. On a new field—let's say for Strategic Air Command—there might be say a million yards of pavement advertised in one of these big jobs. I would estimate that on an average, about three-fourths of that will be in the critical category, and maybe one-fourth of the yardage would be in these functional areas where either one could be bid to us.

Mr. HESS. So there could be, then, in the instance that you cite, 20 percent differential on the one?

General WASHBOURNE. Yes. It could be much higher than that. On the other hand, if you just take a taxiway that is not grouped with any other work, it would be a straight 5 percent deal.

Mr. HESS. So if the cost might be $40 million for the noncritical area, to put it in concrete, and it might be $30 million to put it into asphalt, you would put it in concrete rather than asphalt, and you

would spend the additional 10 million because the overall cost brought it down under the 5 percent differential?

General WASHBOURNE. Well, those figures don't tally, Mr. Chairman, with the jobs.

In other words, I can't think of any of these pavement projects——

Mr. HESS. Percentagewise they do, though, General?

General WASHBOURNE. Exceeded maybe $10 million altogether.

Mr. HESS. On one field, probably not?

General WASHBOURNE. Yes, sir.

Mr. HESS. But percentagewise they certainly do, and over a number of fields your figure would run up to $10 million. It might run greater than that.

General WASHBOURNE. Well, sir; we studied that out pretty carefully as to the dollar effect of this criteria being changed, and it is my information that out of a total pavement program of 200 or 250 million dollars, there was an area of only $15 million affected at the outside.

You see, it works like this. In the first place, we only take the alternate bids where the Government estimate indicates a spread of 15 percent or less between the cost of doing it one way as opposed to the cost of doing it the other.

Well, when you take that spread, you lose probably half or two-thirds of the projects right away one way or the other, depending on other circumstances. So that the criteria doesn't apply to more than 40 percent of the program at all. It couldn't.

Then, within that 15 percent spread on the Government estimates, there are certain inaccuracies. That is the area—only the area in which we take the alternate bids for the critical versus the noncritical; and that area, if I remember correctly, was around $15 million in the $200 million program that we are confronted with.

Mr. BATES. Mr. Chairman——

General WASHBOURNE. Now, that did not represent to us an insurmountable problem in the handling of our pavement dollars.

I have another witness who will give you the exact figures on a chart that are involved in that study. But that is the order of magnitude.

Mr. HESS. Go ahead, Mr. Bates.

Mr. BATES. General, have you found some instances in which the asphalt held up as well on these critical spots as have the concrete?

General WASHBOURNE. I think we would say "Yes" on that.

There have been thousands of yards of asphalt pavement in use by the Air Force and we haven't heard boo about it one way or the other. So I conclude that it is getting along all right.

Mr. BATES. In these critical areas.

General WASHBOURNE. Yes, sir.

Mr. BATES. Then, you would have to question whether in these which were faulty whether they were probably designed correctly or not. It may not be so much the fault of the basic material as the way in which it was done.

General WASHBOURNE. Well, it could. The end result, whether it is the fault of design or the fault of material or the fault of workmanship, isn't really very important because somebody has to pay the bill for fixing it and the people that built it, the contractor, or the material people, naturally don't come along and volunteer to pay

that cost. We usually have to come back to Congress and ask for funds to do the job.

Mr. BATES. I think it is very important, very important to determine, why a certain thing went wrong.

Now when you are dealing with two materials one of which is cheaper than the other, if under certain circumstances the cheaper one holds up and in other circumstances it doesn't hold up, I think it is certainly important to find out why it didn't hold up.

General WASHBOURNE. Well, we agree with you that it is important. But sometimes a failure on pavement is not particularly identified with either materials as opposed to workmanship or one separated from the other.

The operating result is that the pavement is not useful and sooner or later requires some type of extensive repairs or in extreme cases an expensive reconstruction job.

Mr. BATES. Well, can't you tell, after seeing many examples, whether the job was done well or poorly?

General WASHBOURNE. Oh, indeed we can. But the thing is done at that time, Mr. Bates, and we have——

Mr. BATES. It just indicates, General, to me that if it holds up under many circumstances and under some other circumstances it doesn't, that it is not so much the fault of the material itself as the way in which it is handled.

General WASHBOURNE. Well, you can say the same thing for concrete as far as that goes.

Mr. BATES. All right. But we are trying to get the cheaper product, I presume.

General WASHBOURNE. Well——

Mr. BATES. If we are doing something wrong, we ought to try to correct it.

General WASHBOURNE. We feel the suitability of the finished product is primary and that the cost differential is not the primary consideration, although it is very important, I grant you.

Mr. BATES. And we certainly should consider that.

General WASHBOURNE. Yes, sir.

Mr. BATES. And particularly where one, as you say, in many circumstances holds up as well as the other.

General WASHBOURNE. That is right. I am sure that, if there wasn't a cost differential between concrete and asphalt pavements, the Air Force would simply put out a flat requirement for a heavy duty concrete on every yard they want, because that is the operationally suitable pavement; and our commanders are unanimous in preferring it.

I heard General LeMay one time say to a commander who was urging concrete for his project, being better, that "he would like to have diamonds, too, but he couldn't afford them."

In other words, he is aware of that dollar. And he is still, as an operational commander, one of the foremost proponents of increased use of concrete pavement.

Mr. BATES. I would still like to know why when you have one product which under many circumstances holds up while another—on another occasion doesn't, and particularly when it is cheaper——

General WASHBOURNE. I can say, Mr. Chairman, that those three causes of unsatisfactory performance have been identified as materials and workmanship and design.

Now, one of our probably most recently famous asphalt projects over in French Morocco was probably the result primarily of faulty workmanship, rather than faulty materials. But it was pretty hard to make the identification as to which factor caused the most trouble.

Mr. BATES. Well, it seems to me if you get something cheaper we ought to look into the question of workmanship or design.

General WASHBOURNE. Yes.

Mr. BATES. Because both of those factors are in the concrete.

General WASHBOURNE. The construction agencies have told me that they were in a position to produce controlled asphalt, laboratory asphalt I believe they would call it, that would meet all of these requirements. If they could guarantee that the contractors would produce that high quality of surface every time we had a contract, our concern in this matter would be materially reduced.

But unfortunately, they don't control what the contractor produces. And we have lapses in design and inspection and materials and all of those things that occasionally produces a job that is materially below what we would like to have. Sometimes they are very borderline cases and we put up with them.

Mr. BATES. General, do you agree with this statement. Various studies made by Government investigations and others indicate that with a new type of plane, impingement of the blast does not cause serious harmful action, except in small areas where planes may be tied down for testing and repair? Do you agree with that statement?

General WASHBOURNE. No, I am afraid I don't.

Mr. BATES. You don't have any Government reports along that line that you know of?

General WASHBOURNE. Well, I know a good deal of the Government reports that have been made. We have initiated a great many of them ourselves. But I can't agree with the fact that they reach that conclusion.

Mr. BATES. Do you agree with this conclusion: it can be stated positively that there was no reason for loose aggregate being present on a properly constructed asphalt pavement any more than on any other type?

General WASHBOURNE. No, I can't agree with that either.

Mr. BATES. Now, it says "properly constructed." A little while ago you told me under many circumstances it is just as good. Now if it is properly constructed, would you say that this condition is true?

General WASHBOURNE. Well, I have to tell it this way, Mr. Chairman. That is, within my best judgment, properly constructed pavement can be subjected to extremely heavy usage and it will deteriorate under these conditions.

Now the fact that it should not receive such heavy usage or abuse is a problem of operations and perhaps of housekeeping. But I can't agree that, if you reach this certain standard of asphalt, we won't have any more trouble with it. At least I would be afraid to recommend such a course of action in the building of this large pavement program for the Air Force.

Mr. BATES. But under many circumstances today that statement is true today, which you have admitted.

General WASHBOURNE. Well, it is not wholly untrue, that is sure. It is a question of degree and a question of location and many other factors. I don't like to disown it entirely. Don't mistake me there. But neither do I underwrite it without exceptions.

Mr. BATES. The thing we are trying to find out here and determine is why.

General WASHBOURNE. The basic reason why is the fact that the asphalt is soluble under these fuels; and the jet blast and the heat of course simply aids in the damage that is done by the fuel itself, the drippage and spillage.

Mr. HESS. Mr. Hardy.

Mr. HARDY. General, you have indicated that one of the major causes of difficulty with respect to asphalt pavements was the poor workmanship, I believe, haven't you?

General WASHBOURNE. Oh, I think that is true, yes, Mr. Hardy. There have been lots of cases where that happened.

Mr. HARDY. Then it would follow that the reason that we have poor workmanship is because our engineers don't watch their inspection carefully enough; is that right?

General WASHBOURNE. I think if we had complete close inspection of these projects, that we would not have poor workmanship. I think that is right; yes.

Mr. HARDY. Then, it boils down to a failure of supervision by the engineers to see that the proper inspection takes place.

General WASHBOURNE. Well, Mr. Hardy, I——

Mr. HARDY. I am not trying to get you in a position of criticising the Army engineers, but I am trying to get to the bottom of what this picture is.

General WASHBOURNE. Well, I would like to point out that there are so many steps involved in the inspection of these asphalt paving contracts, you can't just say that the inspector was asleep or didn't do a good job. It goes way back of that.

Mr. HARDY. There are a lot of steps in the inspection of any complicated construction.

General WASHBOURNE. Yes, sir; that is right.

Mr. HARDY. But nevertheless, it needs to be done properly.

General WASHBOURNE. For sure, yes, sir.

Mr. HARDY. And if it isn't done properly, if your inspection isn't done properly, then it is certainly a reflection on the engineers that are responsible for supervision.

General WASHBOURNE. Yes, sir, on whoever inspects it, regardless.

Mr. HARDY. Now, then, one other aspect of this discussion, Mr. Chairman.

Awhile ago you made reference to a 15 percent variation in Government estimates.

I understood that that had reference to being a basis for a determination as to whether you would get bids, alternate bids.

General WASHBOURNE. That is right.

Mr. HARDY. Is this Government estimate that you referred to comparable to the engineering estimate that Captain Kehart referred to this morning?

General WASHBOURNE. Oh, yes.

The Bureau of Yards and Docks has been asked to use that same spread in determining their work, that they do for the Air Force, the

same as the Corps of Engineers. That is a directive that I sent out, and it went to them, too, I believe.

Mr. HARDY. I am just trying to understand this picture. Now, in arriving at the type of estimate which you use, is that based on drawn up specifications for that particular job both ways?

General WASHBOURNE. Well, we give the construction agencies broad definitives of what kind of pavement we want, the wheel load and the dimensions, and they set about making their engineering estimates in their own fashion. And lots of places, one of the pavement types is out with very superficial examination, such as down in Louisiana where you have a high water table, which is right around the roots of grass and you know asphalt isn't going to work and you don't spend much time studying it.

But if the two types of pavements look like they will be pretty close bidding, we just ask them, within a 15 percent area, to give us alternate—a chance to take alternate bids.

Mr. HARDY. So, then, whenever you specify concrete throughout, that is an indication that the engineers have failed to find a differential in their estimate of as much as 15 percent?

General WASHBOURNE. No, not necessarily, Mr. Hardy. We sometimes ask the construction agencies to build a pavement one way or the other for a completely different reason. For instance, I recall that the big new pavement out at Edwards Air Force Base that we put under construction last year—we specifically asked that that be made of reinforced concrete on account of the particular functions that it was expected to serve.

Mr. HARDY. Well, let me put my question in a reverse way.

Can it be assumed that whenever you have asked for bids both for concrete and bituminous, the engineers did make an estimate that there was 15 percent or more difference in the cost?

General WASHBOURNE. Fifteen percent or less, Mr. Hardy. In other words, if the spread—if the estimated cost of concrete is more than 15 percent above the estimated cost of asphalt, they don't bother about this alternate bidding. So let the contractor say what the difference is really going to be. Because I think everybody will agree that our estimating procedures are not that refined and there could be Government estimate that says that the difference in cost to be 12 percent and the——

Mr. HARDY. Maybe I don't undertsand this thing, General. If the estimate is that concrete will cost more than 15 percent in excess of asphalt, then you would not take alternate bids?

General WASHBOURNE. That is right.

Mr. HARDY. And what would you take then, just asphalt?

General WASHBOURNE. No. We would adverise for the combination of asphalt—I mean of concrete on the critical areas and asphalt on the noncritical areas.

Mr. HARDY. In that situation, you would split your bid?

General WASHBOURNE. Well, it isn't split. It is just the way the project is laid out.

If I understand what you mean, I think I agree that that would be called splitting the bid; yes.

Mr. HARDY. Well, it is the kind of the split we were talking about in here this morning when we were discussing the matter with Mr. Ferry, I believe.

General WASHBOURNE. Yes; I thought so then and I still believe that is what you mean and we mean.

Mr. HARDY. That is what I am driving at.

Now, Mr. Chairman, I would like to know whether the Navy uses any percentage figures similar to that.

Mr. HESS. This morning, the captain testified that they did not. Am I correct?

Captain KEHART. Yes.

Mr. HESS. Captain Kehart testified this morning that the Navy does not use the differential.

Mr. HARDY. They don't use any percentage figure—if they just guess that it is going to be more expensive to use asphalt, or approximately, why, they go ahead with concrete. Is that the way you understood it?

Mr. HESS. That is correct.

Mr. HARDY. That is the way I understand it.

Mr. HESS. Is that all?

Mr. HARDY. Thank you.

Mr. HESS. Mr. Fisher.

Mr. FISHER. General, I was particularly interested in the extent of the research that you say has been done in recent years with respect to trying to improve the quality of the material that goes into this runway construction. I believe you estimated the Air Force itself has put perhaps $5 million in that.

General WASHBOURNE. Yes.

Mr. FISHER. Just who does that experimenting? The Army engineers or——

General WASHBOURNE. Yes; they are the actual experimenters. They have the well known laboratory for flexible type pavements down at Vicksburg, Miss. They have concentrated on the rigid types primarily at the laboratory up at Cincinnati. I think they have done some—they have specialized in some arctic experimentations at one or two places, which I have forgotten just where it is.

In addition to those laboratories, they have put field observation teams out through the country and overseas, to get the same information and to pick up dope on procedures and continental practices and all that sort of thing.

Mr. FISHER. It would seem then, that that would be a very good source of expert technical information, that would throw more light on this general subject. Wouldn't you think so?

General WASHBOURNE. Well, it is, Mr. Fisher, up to the point where you introduce this problem of jet propulsion.

That is the field in which we have a considerable amount of concern and not a matching amount of information, yet.

Mr. FISHER. I assume their studies, however, have included the effects of jet propulsion on these various runways?

General WASHBOURNE. Well, a great number of test strips or test panels as you might call them, have been put down at many places with an idea of testing the effect of jet operations and spillage and that sort of thing, and some of the cost of those are included in this cost of the investigation.

Now, those test panels are put down at various places. I recall one down at Hunter Field, at Savannah, Ga., that was put in about 2 years ago. It has had a pretty good run. I conferred with rep-

resentatives of the Chief of Engineers in about July 1952, to see if the results of the Vicksburg experiments were going to give us an answer on this problem right away because the '52 and '53 program had a lot of money in for pavements.

The summary of what they told me was that they wouldn't have anything dependable for at least a year. That would be in the summer of 1953. Well, we knew about this tar rubber having been proposed as a means of improving asphalt surfaces. So we set up six pavement projects and put directives out that they be constructed of asphalt surfacing with this tar rubber wearing course.

In other words, that was done at our expense just to make sure we did get some rather extensive pavement surfaces upon which we could get some better dope and do it faster than the experimental panels were giving it to us.

Unfortunately, for one reason or another, those panels have been delayed pretty badly and they haven't been of much use to us up to now.

Several of them have been completed. The one up at Presque Isle, Maine, has reported very satisfactory results. And generally, they concluded that no significant damage had occurred on that test strip up there during the time they have been using it.

Mr. HESS. I am sorry, I have to interrupt at this time.

That is a roll call vote and we are going to have to take a recess for a few minutes, maybe 15 or 20 minutes, and then we will be back and we will resume the hearing.

General WASHBOURNE. Very well, sir.

(Recess taken.)

Mr. COURTNEY. To all the witnesses present, the chairman has just called from the House floor and states that there will be two roll call votes on a pending bill. For that reason, he does not want to hold the witnesses here against an uncertain return, for which reason we will adjourn until tomorrow morning, Friday, at 10 a. m.

(Whereupon, at 3:35 p. m., a recess was taken, to reconvene at 10 a. m., of the following day, Friday, February 5, 1954.)

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AIRSTRIP PAVING MATERIALS

FRIDAY, FEBRUARY 5, 1954

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON DEFENSE ACTIVITIES OF THE
COMMITTEE ON ARMED SERVICES,
Washington, D. C.

The subcommittee met in room 304, Old House Office Building, at 10 a. m., the Honorable William E. Hess, chairman of the subcommittee, presiding.

Mr. HESS. The committee will come to order, please.

General, would you mind coming forward and take the stand, again?

I think Mr. Nelson has some questions he wants to propound to you this morning, General.

Mr. NELSON. General, in the first place; as I understand it, it was testified yesterday that the airbase at Thule in Greenland was constructed of concrete. That is not true, is it?

TESTIMONY OF MAJ. GEN. L. B. WASHBOURNE—Resumed

General WASHBOURNE. No, sir; that is not true. General Ramey was in error on that.

Mr. NELSON. The airbase then at Thule is constructed entirely of asphalt?

General WASHBOURNE. I don't know of any concrete. There may have been portions of the apron that were in concrete. I can't recall. But my recollection is that that is an asphalt job.

Mr. NELSON. Has it been satisfactory?

General WASHBOURNE. I haven't heard of any reports on that one either way, Mr. Nelson. I presume it has been doing all right.

Mr. NELSON. The SAC base at Limestone, in my own State of Maine, is constructed of asphalt, is it not?

General WASHBOURNE. Yes, I believe that is entirely a blacktop job.

Mr. NELSON. General, I would like to reduce this problem to some size that the committee can properly comprehend. Would you tell the committee how many airbases in the United States are using jet fighters and how many of these airbases are constructed of asphalt and how many of concrete?

Mr. HESS. You want the jet fighters or jet planes?

Mr. NELSON. Jet planes.

General WASHBOURNE. I don't believe I can do it offhand, Mr. Nelson. It would involve numbers that will have to be counted up.

Mr. NELSON. Well, General, would you furnish the committee with that information?

General WASHBOURNE. Yes, I will be glad to.

Mr. NELSON. And offhand, not pinning you to any accuracy, can you give us some general idea of the magnitude of the situation?

General WASHBOURNE. I find I am unable to recall the first part of the question, Mr. Nelson.

Mr. NELSON. I want to know how many airbases are using jets and of those airbases how many are built of asphalt and how many of concrete.

Mr. FISHER. How about the Navy?

Mr. HESS. We will get that from the Navy.

General WASHBOURNE. In round figures, we probably would be operating 200 airdromes for flying purposes in the United States.

I am unable to break them down as between jet fighters and bombers and transports, offhand. I don't think that makes any real difference, because while not all of our planes are jet propelled now, they probably will be in the foreseeable future. So that for the purposes of the problem, we have to approach it from the standpoint of an all-jet Air Force. Some of our planes, as you know, like the B–36, have both the jet engines and the piston engines on them at the same time. Others may be converted from one powerplant to another later. That is problematical.

Now of that 200 flying fields, I would guess offhand that 50 of them have concrete runways and the other 150 may have blacktop. But I could be way off on that guess.

Mr. HESS. Do you want the figures?

Mr. NELSON. Yes, I would like to have the figures.

Mr. HESS. General you will furnish that.

General WASHBOURNE. I will furnish this for the record.

Mr. HESS. At this point, Captain Kehart, I wonder if you would furnish the same information as to the Navy, those fields which are of concrete and those fields which are of macdam or blacktop, and how many of your Navy fields jet planes are operating off of.

General WASHBOURNE. Your reference, Mr. Nelson, was as to the runways?

Because nearly every field has both types on it. So it would be difficult to classify them except as to certain feature.

Mr. NELSON. I take it when you furnish the committee the information you can specify the information as to the fields that have asphalt aprons and runways.

General WASHBOURNE. Yes, we can break down the yardage as between the two when we have both.

(The breakdown was furnished later by General Washbourne for insertion at this point:)

Attached is a list of a majority of all Air Force airfields in the United States where jet aircraft are based. The list shows the total pavement yardage for each facility—aprons, runways, others (taxiways and warmup pad) and the type of pavement (concrete or asphalt) of which each facility is constructed.

It will be noted that of the 88 fields listed, 16 have all concrete aprons, runways, taxiways, and warmup pads. Only four fields have all asphalt aprons, runways, taxiways, and warmup pads. The remaining 68 fields have combinations of both asphalt and concrete.

It is desired to bring to your attention that jet aircraft are operating from all Air Force fields during the course of routine training or practice mission flights.

Pavement

[Square yards]

Base	Apron		Runway		Other (taxiways and warmup pads)	
	Asphalt	Concrete	Asphalt	Concrete	Asphalt	Concrete
Barksdale		809,200		638,900		301,600
Lake Charles		562,700		222,222		130,545
Turner		347,332	149,867		279,442	1,966
MacDill	528,661	199,688	675,005		834,153	
Lockbourne	245,506	931,995	124,444	101,443	60,833	22,222
Bergstrom		272,463	430,000	12,501	259,590	
Davis-Monthan	246,000	589,300	255,555		1,109,350	61,300
March	192,033	723,855	338,555		311,356	25,783
Dow	157,748		233,333	13,332	248,471	142,145
Hunter	547,368	198,803	233,376		364,391	
Great Falls	86,710		652,777		217,208	
Pine Castle	183,251	217,037	152,933	266,711		291,110
Ethan Allen	19,275		252,890		40,039	49,212
Greater Pittsburgh	5,500	84,627	286,668	12,217	41,792	237,398
Kinross		183,466		425,869	42,765	22,549
Youngstown		41,590	282,005		340,054	22,691
New Castle	91,000	18,650	422,221		174,054	29,955
Niagara Falls		42,200	410,214	125,000		62,050
O'Hare	202,813	263,519		405,465		62,100
Otis	180,587		516,668		301,030	161,075
Presque Isle	64,826	36,800	322,873	32,927	166,903	12,772
Selfridge	60,000	320,650	36,667	100,000	36,579	31,063
Stewart		233,288	143,218	226,782	83,395	106,578
Suffolk		87,726		276,809		123,264
Truax	14,638	166,411	412,650		126,127	
Wurtsmith		47,791		333,824		124,938
Duluth	26,072		320,777		72,267	
Grandview		90,152		294,283		90,484
McGhee-Tyson		45,541		208,333		88,933
Minneapolis-St. Paul		72,000		252,777		14,815
Sioux City		262,872		350,080	45,800	162,440
Yuma		236,700	280,200		205,600	15,000
Peterson		108,160	401,712	21,388	26,389	
Oxnard	53,333	4,982	128,333	5,000	79,449	3,400
Hamilton		186,616	318,762	107,571	84,697	47,367
Portland	50,000	57,200	676,700	33,900	218,330	34,700
McChord	163,711	161,640	155,000	13,333	296,696	109,050
Paine		24,496	229,589	17,090	204,324	43,598
Geiger	28,179	127,132		386,400	18,272	146,393
McGuire	85,113	138,093	330,001	46,527	71,722	116,582
Holloman	140,025	353,467	415,017		437,406	
Edwards		31,275	359,617		71,777	12,299
Kirtland	86,948	367,656	615,550		444,980	146,400
Patrick	79,957	448,439	388,065	22,332	93,472	
Andrews	78,647	144,651		428,178		183,856
Dover		35,346	232,499			300,635
Brooks	42,456	17,706		251,399	19,000	14,789
Dobbins		193,466		232,429		45,532
Eglin:						
Main	97,100	229,639	583,998		321,336	
No. 3		25,000	414,569		50,006	
No. 2		25,000	333,333		51,526	
Maxwell	47,873	478,105	839,332		85,732	104,443
McClellan	138,436	598,504	267,296		64,434	
Norton		327,948		289,916	5,358	103,946
Robins	33,097	33,409		370,633	73,172	
Tinker	26,752	974,703		354,685		121,787
Wright-Patterson		377,188		459,702		224,500
Alexandria		181,000	61,000	350,000		329,000
Clovis		168,000	1,011,000		143,000	260,000
George	258,000	165,000	666,000	152,000	80,000	279,000
Foster		274,000		745,000		61,000
Langley		334,000		231,000		339,000
Larson		125,000		1,111,000		365,000
Eglin auxiliary No. 9		29,000	78,000		18,000	
Shaw		177,000	69,000	167,000	114,000	231,000
Amarillo	24,600	211,800	281,556		101,800	
Gila Bend (Luke)	1,042	41,111	276,667		22,527	36,667
Craig	143,954	12,126	929,985		153,783	7,333
Moody		131,517	499,654	174,597	122,245	201,144
Greenville		103,736		875,334		256,135
Connally		420,040		312,667		284,725
Nellis	2,374	446,246	447,082		192,310	141,897
Keesler		222,455	188,750		42,601	
Perrin	32,261	62,974	308,500		419,028	102,511
Laredo		230,489	409,766	319,466	134,916	154,954
Randolph	71,714	515,874	262,777	466,668	13,473	374,643

Pavement—Continued

[Square yards]

Base	Apron		Runway		Other (taxiways and warmup pads)	
	Asphalt	Concrete	Asphalt	Concrete	Asphalt	Concrete
Eagle Pass				125, 200	43, 588	
Scott	33, 573	62, 801		380, 817	104, 325	32, 192
Laughlin		130, 708	374, 599		305, 968	105, 208
Tyndall		208, 139		584, 895		227, 104
Lowry	109, 860	367, 256		310, 395	6, 096	230, 972
Apalachicola		46, 830		260, 001		108, 447
Luke		222, 526		256, 517	37, 016	150, 844
Webb		148, 803	585, 983		192, 094	92, 167
Luke Auxiliary No. 1			595, 366		48, 888	
Williams	101, 578	199, 138		64, 082	496, 690	207, 621
Williams Auxiliary			883, 004		96, 799	
Wichita	4, 000	318, 890	422, 748	301, 416	30, 000	479, 542

Mr. NELSON. I wouldn't expect you to give it offhand.

Captain KEHART. Mr. Chairman, you want that in numbers only, sir, or specifically in length of fields?

Mr. NELSON. Numbers and yardage.

Captain KEHART. Yardage. All right, sir.

General WASHBOURNE. On the jet fighters, there are about 60 fields used by those interceptor squadrons. About half of them are Air Force bases and the other half are municipal airports with some kind of a joint-use arrangement.

Mr. NELSON. How many of these 150 fields where you have asphalt have you had complaints from the base commander as to the nonperformance of the asphalt?

General WASHBOURNE. Well, I believe I would have to interpret the expression "complaints from base commanders" to include the submittal of repair projects of any magnitude to correct their troubles. If that is agreeable to you—just a minute.

Mr. Nelson, I believe it would be correct to say that we probably had a complaint or a major repair project on perhaps 2 dozen of the fields. There has been a much larger number of repair projects that are executed within the approval of the base commander's authority and we probably wouldn't hear of it except by digging through the records to identify such coded expenditures.

Mr. NELSON. I am sure the committee doesn't want to unduly burden the Air Force, and yet at the same time, General, we are very anxious to get at the facts behind the policy which the Air Force has adopted.

General WASHBOURNE. I can appreciate that.

Mr. NELSON. I would appreciate it very much if you would furnish the committee with the type of complaint you are getting and the type of repair that has to be made to these asphalt runways.

General WASHBOURNE. We will be glad to.

(The following was received by General Washbourne for insertion at this point.)

Complaints received from the commands include reports of damage to asphaltic pavements caused by: (1) Jet fuel spillage, (2) softening of pavement surface, (3) pavement aggregate blown out by jet blast, (4) rutting in hot weather by high-pressure tires, (5) failure by overloading, (6) raveling of old pavements from long inactivity, (7) erosion of pavement surface by jet blast, (8) softening of pavement by heat of blast, (9) skidding during high-speed landings, (10) rutting of softened pavements by engine maintenance stands and hard-wheel maintenance equipment, (11) tracking softened asphaltic surfaces by aircraft

wheels and wheels of other vehicles and on shoes of aircraft crews, (12) faulty construction joints causing aircraft to swerve at high speeds, (13) poor construction due to inadequate inspection and poor-construction technique.

A typical list of repair projects follows. These projects do not reflect the small repair requirements accomplished by day-to-day maintenance performed under the supervision of the base Air installation officer.

REPORTS OF ITEMS ON AIRFIELD PAVEMENTS

Item 1—Eglin AFB, Fla. May 21, 1952.—Request for reprogramming. $98,000 to correct deficiencies in runway at auxiliary No. 2 caused by jet-fuel spillage. No yardage given. 6,000 foot runway.

Item 2—MISAWA AB, Japan, June 5, 1952.—90,000 square yards aircraft-dispersal area, $200,000 for reconstruction. Project justification, jet-fuel action on asphalt pavement, heavy traffic and abnormal weather conditions.

Item 3—Moody AFB, Ga., January 30, 1953.—Surface of new asphalt concrete primary runway and taxiway deteriorated. Damage due to jet-fuel spillage. Considerable patching accomplished locally. Project for applying jet fuel resistant fuel surface seal on 68,900 square yards $30,140.

Item 4—Oxnard AFB, Calif., September, 1953.—New asphalt apron in areas around fueling hydrants damaged by fuel spillage. A project to restore the pavement was approved at a cost of $18,095.

Item 5—Pinecastle AFB, Fla., January 22, 1953.—Considerable damage to asphalt airfield pavement surface due to repeated jet-fuel spillage. Project for sealing 300,000 square yards of pavement with JFR surface sealer, $160,000. This project was approved and then deleted from maintenance and operation program when all F–80 and F–84 jet-type aircraft were phased out of the base-training mission and T–33 jet aircraft were moved to a newly constructed portland cement concrete pavement.

Item 6—Truax AFB, Wis., July 31, 1953.—Ends of asphalt concrete runway seriously damaged by F–89 jet aircraft. Project for replacement for these areas, approximately 18,000 square yards was approved in the amount of $88,000.

Item 7—Williams AFB, Ariz., new aircraft parking area.—A project to overlay this apron with a tar-rubber surface is soon to be let to contract: 100,000 square yards costing approximately $200,000.

CONDITION OF AIRFIELD PAVEMENTS NOT DUE TO JET FUEL SPILLAGE

Tactical Air Command reported April 1, 1952, to USAF, newly constructed asphaltic airfield pavement Stewart AFB, Tenn., Clovis AFB, N. Mex., not completely satisfactory and on December 23, 1953, reported unsatisfactory construction of asphaltic apron at Donaldson AFB, S. C.

(*a*) Observed deficiencies at Stewart and Clovis are—

(1) Open taxiway surfaces.

(2) Faulty construction joints.

(3) Irregular roller marks on surface.

(*b*) Possible causes—

(1) By variation in gradation of aggregates.

(2) Season of year constructed.

(3) Construction methods used.

(4) Inadequate inspection.

(*c*) Corrective measures—

(1) Stewart AFB, Tenn.: Bituminous seal coat, 230,000 square yards, $40,000.

(2) Clovis AFB, N. Mex.: Bituminous seal coat, 472,000 square yards, $51,000.

(*d*) *Donaldson AFB.*—New asphaltic apron appears satisfactory except the top wearing surface (1½ inches). Poor inspection resulted in inadequate tack coat (asphaltic coating between the binder and wearing courses) which permits the wearing surface to peel; improper densities and excessive rolling after the material became cold causing cracking and laminations; and inadequate surface drainage by reason of setting the drainage inlets too high.

It is proposed to apply a seal coat to the surface after making local repairs and lowering the drop inlets. The cost is estimated at approximately $35,000. The drainage situation will be corrected but the inherent weakness in the wearing course will not be corrected except by complete reconstruction. No estimate can be made at this time when such reconstruction will be necessary.

Travis AFB, Calif.—Failure of bituminous intermediate areas, between portland cement concrete parking stubs—B–36 parking—maintenance area observed by Mr. Benson and Mr. Crowley in spring 1952. Failure apparently caused by

excessive spillage aviation gasoline and lubricating oil. Approximately 10,000 square yards involved.

Air Defense Command.—Has reported that projects were approved for application JFR surface sealing compound in areas damaged by jet fuel spillage at following bases: Selfridge AFB, Mich., Paine AFB, Wash., Otis AFB, Mass.

Mr. NELSON. Now, how many of these air projects have been submitted or complaints received on the fields that have concrete runways?

General WASHBOURNE. Subject to correction from the record, Mr. Nelson, there are no complaints or major repair projects involving concrete runways.

We have had a few repairs—spalling troubles and the like—which have been local, the same way as these minor ones on asphalt. It might be possible to identify some in the lower category of repair projects under $5,000 apiece. I just don't know without looking.

(The following was received from General Washbourne for insertion at this point:)

There are numerous examples of difficulties with concrete pavements. However, the difficulties arose as a result of overloading; that is, operating aircraft at loads far in excess of that for which the pavements were designed. The following examples are cited:

Carswell AFB, Tex.—An old runway was being used as a taxiway and parking area for B–36 aircraft. It was so badly cracked that the edges of the cracks chewed up the tires. The same thing occurred on the main taxiway connecting the main parking apron and the new heavy load runway. Pending reconstruction of the taxiways, maintenance and operating funds in the amount of approximately $400,000 were expended to construct asphaltic overlays on the damaged concrete pavements.

Travis AFB, Calif.—A project for reconstructing one end of an existing runway was recently completed. The concrete pavement was so badly cracked because of overloading by B–36 and C124 aircraft, operations on this particular runway were limited to light aircraft. Widening, strengthening, and extending this runway was accomplished at the same time in order to provide a fully operational facility.

Goose Bay Airport, Labrador.—The existing concrete pavements constructed in 1942–43 served well until B–36 and B–47 aircraft operations became more frequent during the past year. It was discovered that as a result of these operations slab failure was increasing and pavement settlement occurred. One area of settlement was blamed for the blowout of 12 tires on a flight of jet fighters that landed at the base during a routine flight. It is now proposed to strengthen this runway with an asphaltic concrete overlay to sustain HB aircraft before the runway becomes inoperational.

Wichita AFB, Kans.—Reconstruction of all concrete pavements to meet heavy load requirements is now underway. All the original pavement was inadequate from the standpoint of loading to support B–47 operations.

Mr. NELSON. What experience from an engineering standpoint has the Air Force had as to longevity between asphalt and concrete? To point up the information I would like to get, General: How old are your concrete runways?

General WASHBOURNE. It is difficult to give a brief answer to that, Mr. Nelson. Before 1930 we built a great many concrete runways and concrete aprons, because the art of asphalt wasn't too dependable in that period.

Then during the period of World War II, where construction was pretty urgent and speed of completion was very important, we built a majority, I would say, of the asphalt types.

Then beginning in late 1944 and 1945, when the B–29 began to show up and people began to realize what the problem would be, we built a great number of these heavy concrete jobs, like at Barksdale,

Mountain Home, Kirtland Field, North and South Carolina, and other places—yes, Patterson Field is a good example, which the committee may have visited.

At the same time of course we didn't rule out the asphalt and big fields like Limestone, which were started as early as 1947, I believe, were put up in the asphalt. So there has been no particular pattern which we held to on the runways in any given period.

Mr. NELSON. Just to clear up one thing in my mind: You say some of these repairs were undertaken by the base commander?

General WASHBOURNE. Oh, yes.

Mr. NELSON. How much of an allowance does the base commander have?

General WASHBOURNE. Normally he can approve a local project up to $5,000 out of his maintenance and operations funds, and that is all there is to it. They simply go out and repair it.

Mr. NELSON. And anything over that he has to come to you for?

General WASHBOURNE. Yes. Over $5,000 and up to $25,000, the major commander has to approve it and clear it. If it is over $25,000, it has to come in here to Washington for processing as to essentiality and the furnishing of the funds.

Up until 2 years ago we had the major commands operating both in the ZI and overseas at a $50,000 limitation. So at that time only the $50,000 and up came in here.

So it would be proper for the committee to realize, I think, that the local commander has a $5,000 approval authority. The major commander has a $25,000 approval authority. And the Secretary of the Air Force has from $25,000 to $50,000, and if it goes on up from there, it has to go through the Secretary of Defense I believe.

Mr. HESS. Will the Gentleman yield right there?

Mr. NELSON. Yes.

Mr. HESS. Just to clear that up a little bit farther, General, would you explain just what you mean by the $5,000 limitation? Is it a $5,000 limitation on any particular repair job on the field?

General WASHBOURNE. Yes.

Mr. HESS. So he might have one repair job at five and another at five and another at five and another at five. He may have 20 of those and it would run up to $100,000?

General WASHBOURNE. Yes, sir.

Mr. HESS. And he would be permitted to expend that amount of money?

General WASHBOURNE. That is right.

Mr. HARDY. Mr. Chairman, may I pursue that just a little further?

Mr. HESS. All right. If the gentleman from Maine yields? He has the floor.

Mr. NELSON. The gentleman from Maine is glad to yield, so long as he returns to the floor.

Mr. HARDY. General, ordinarily in the case of necessary repairs to an asphalt runway that would be done before the size of the project got up to $5,000, wouldn't it?

General WASHBOURNE. It ought to be, Mr. Hardy, but we found some of the base commanders haven't taken as good a care of their properties as they should have. I would say that the local commanders have not kept on top of the problem. But you are quite right. They should repair them and most of them do when it oc-

curs, and it may be only a very minor deal, like say a damaged area as big as this table. He just goes out and fixes it and that is all there is to it.

Mr. HARDY. Now, that is the way I had understood it was done. I think Mr. McCloud will remember. We inspected certain damage spots a lot smaller than that table in most cases I think, and we understood that the base commander was just having them fixed.

General WASHBOURNE. That is right. That is the way it is supposed to be done.

Mr. HARDY. And the amount that would be involved in a single project would be very small.

General WASHBOURNE. Might be—yes—down as low as a $5 job.

Mr. HARDY. That is right.

General WASHBOURNE. Just go out and fix it.

Mr. FISHER. Of course, you were speaking ceilings there under local authority?

General WASHBOURNE. Yes.

Mr. FISHER. When you spoke of $5,000.

General WASHBOURNE. In other words, I was trying to clear up the magnitude of the great number of instances that would have to be identified and reported for Mr. Nelson.

Mr. HESS. All right, Mr. Nelson.

Mr. NELSON. General, what is the practice of the Air Force with regard to covering concrete runways with asphalt or putting a concrete overlay over asphalt itself?

General WASHBOURNE. Well, I don't say we do have a policy, Mr. Nelson. Normally, the way to repair a piece of pavement that needs an overlay is recommended by the Corps of Engineers, when it is a major job, and that is what I assume you are referring to.

There is no question about it, as Captain Kehart said yesterday, that a concrete overlay is expensive because the minimum thickness that you can put on to make it hold is about 6 inches and lots of times an overlay—you would like to make it 3 or 4 or even 2 inches. In such cases the decision usually goes to asphalt on the traffic areas.

Now on these aprons, we used to overlay them with asphalt, but I think now that our preference would be to minimize that wherever we could on the cost factor.

Mr. NELSON. Have those asphalt overlays worked out satisfactorily?

General WASHBOURNE. Well, some of them haven't reported any great amount of trouble. Some of them have been the source of these repair projects that have come in. The Training Command has reported increasing trouble with aprons that were either built of asphalt in the first place or were overlaid with asphalt later. Generally speaking, an asphalt overlay on an apron is the same problem as building it with asphalt in the first place. And that is the area in which we designate as critical and prefer it in concrete.

Mr. NELSON. The asphalt runways have worked satisfactorily, where you have overlaid it with concrete?

General WASHBOURNE. No, sir. The asphalt on runways, either overlay or initial construction, is not equal to concrete.

Now the degree in which it is unsatisfactory is the nature of our problem. As General Ramey said yesterday, we have had a number of instances of damage to runways and taxiways other than at the

ends. The extent of that heretofore has not been too great, but it is becoming enough of a problem where we have to face up to it.

Mr. NELSON. Well, give us some instance of the magnitude of the problem. In how many instances have you had complaints about asphalt overlays on the runway?

General WASHBOURNE. The number of instances where we have a major command complaint about a runway overlay, Mr. Nelson, is pretty limited. I could think of maybe 3 or 4. Most of those are minor items which are probably patched on the spot and we wouldn't come to hear about it.

Mr. NELSON. Would you furnish the committee with that information?

General WASHBOURNE. Yes, sir, be glad to.

(The following was received by General Washbourne for insertion at this point:)

Concrete runways that have been overlaid with asphalt are limited to such recent major projects as Ramey, Lockbourne and Ellsworth. No operational complaints are of record. However, Strategic Air Command protested the excessive design thickness at Ellsworth and Lockbourne because of high cost. An arbitrarily reduced design was accepted.

There have been complaints regarding asphalt overlays on concrete aprons. These complaints, resulting from jet fuel spillage and erosion by jet blast, are similar to those received in regard to asphalt pavements in general. The most notable case cited is MacDill Air Force Base, Fla. However, exceptional housekeeping measures have aided materially in alleviating the condition. Such measures include catching fuel in buckets or pans when engines are cut, flushing the pavement with water (carried in buckets), or with fire extinguishers, when spillage occurs during fueling operations.

The problem arises from the fact that although a runway may be 10, 12,000 feet long, with a concrete block on each end, there are 2, 3, or even 4 connecting taxiways at the quarter points or the third points at which airplanes slow down and turn off the runway. That is the usual place where that turning occurs that we have that damage.

Mr. NELSON. Well, do I understand that the Air Force has on most of its bases at the end of the runway warmup pads, so-called?

General WASHBOURNE. It used to be called warmup pads. It is not a very accurate term with jets, but it is the same place.

Mr. NELSON. What is it called with the jets?

General WASHBOURNE. Well, I have called it aircraft stacking pads and traffic pads and warmup pads.

Mr. NELSON. What are those constructed of, General?

General WASHBOURNE. They are concrete; should be.

Mr. NELSON. Well, are they?

General WASHBOURNE. Most of them are.

Mr. NELSON. Now, General, you testified yesterday that with relation to this new treatment of asphalt, with rubberized cover or something—you would call it.

General WASHBOURNE. Yes.

Mr. NELSON. That if the asphalt people would guarantee the construction along that line you would be perfectly satisfied with it? That is as I recall your testimony. I am not trying to pin you down.

General WASHBOURNE. Yes, sir; that is the nature of the problem. In other words, if we had a sure cure where we would get a completely satisfactory job every time without having the hazard of rebuilding it or fixing it up, no question about the asphalt surface

and the asphalt construction generally will hold the weight of these planes as far as actual holding them up.

Now, there is a quetsion as to whether or not these very heavy tire pressure of upward to 200 pounds per square inch won't damage asphalt surfacing, even though the weight of the airplane is not a factor. That has been a problem and I am sure it still is. They may get even higher in the footprint pressure and the surfacing gets knifed.

Mr. NELSON. Have you had any experience with that to reach a definite conclusion as yet?

General WASHBOURNE. Not a definite conclusion; no. We just know there is a problem and the problem is getting worse.

Mr. NELSON. Well, now, General, you do have some difficulties with concrete, do you not, due to poor workmanship or something or other?

General WASHBOURNE. Oh, I think so; yes. We have had some fields where we had spalling problems and the joints would leak and water would get in and freeze and cause trouble, a minor amount I would say; yes.

Mr. NELSON. The concrete people don't guarantee that they will put the concrete in just according to your specifications, do they?

General WASHBOURNE. Unfortunately, nobody guarantees the job. We go out and pay for it and it gets built for us and we accept it. If it turns out to be without fault it is fine and if it turns out to have a fault it is just too bad.

Mr. NELSON. Now, General Ramey testified yesterday that to the best of his recollection he knew of one accident that had been caused to aircraft by an asphalt runway. Do you recall that testimony?

General WASHBOURNE. Yes; I heard his testimony.

Mr. NELSON. Do you have any record of any accidents that have been caused to aircraft by a concrete one?

General WASHBOURNE. Mr. Nelson, that is being looked up now. I would like to put the information we get into the record at this point:

No major accidents have been reported which could be attributed to concrete pavements.

Mr. NELSON. Just so we get it. Now, you used all of asphalt at Limestone?

General WASHBOURNE. I believe that is correct, yes, sir.

Mr. NELSON. Now, what do you propose to do with regard to air bases in the Limestone category—Limestone and Thule—and have you constructed any other air bases recently of asphalt or are those the only two?

General WASHBOURNE. Mr. Nelson, we built a lot of pavement in Iceland this past year and that is black top. We are waiving our criteria with respect to the field at Homestead, Fla., and are going to build that entirely of asphalt becaues of the underlying coral there.

The difference in estimated cost at Homestead, Fla., between asphalt and concrete is around $3 million. We just couldn't find a reason to pay $3 million for the concrete formula there in terms of prospective damage and repairs ,and so we went for all asphalt on the basis of a special case.

Most of the overseas pavements are going for black top because of operation conditions. But they have their share of troubles.

I recall a few months ago I was at Brize-Norton in England, and the base commander showed me where the field was becoming so

rough and wavy that the B–47 pilots were just shaken out of their seats. They could hardly hang on to the controls before they got airborne. And he had a heavy overlay problem that he had to pay for. The British Ministry is going to handle it.

Mr. NELSON. What is that overlay going to be?

General WASHBOURNE. What is it going to be?

Mr. NELSON. Yes.

General WASHBOURNE. I don't believe he said. I was with the British engineer at the time and he mentioned putting in concrete for the shoulder stabilizations, but I don't know what he said he was going to use for the runway overlay.

To get back to your question, I can't think of any Zone of Interior runways that are going except in concrete at the moment, but I would like to leave that open and correct the record.

(The following was received by General Washbourne for insertion at this point:)

Following is a list of Air Force construction projects recently completed or in progress showing those facilities which are asphaltic or concrete construction:

Bryan Air Force Base, Tex.:
- Runway, concrete
- Taxiway, concrete
- Apron, concrete

Andrews Air Force Base, Md.: Apron, concrete

Alexandria Air Force Base, La.:
- Runway (extension), concrete
- Taxiway, concrete

Wichita Air Force Base, Kans.:
- Runway, concrete
- Taxiway, concrete

Perrin Air Force Base, Tex.:
- Runway, concrete
- Taxiway, concrete
- Apron, concrete

Forbes Air Force Base, Kans.:
- Taxiway, concrete
- Apron, concrete

Reese Air Force Base, Tex.: Apron, concrete

Webb Air Force Base, Tex.: Apron, asphalt

Laredo Air Force Base, Tex.:
- Taxiway, asphalt
- Runway, asphalt

Walker Air Force Base, Tex.:
- Taxiway, asphalt
- Apron, asphalt

Edwards Air Force Base, Calif:
- Runway, concrete
- Taxiway, concrete
- Apron, concrete

Mr. NELSON. Have you ever had any operational complaints from Limestone?

General WASHBOURNE. Yes, we did. We had an operational complaint there——

Mr. NELSON. Just one?

General WASHBOURNE. What?

Mr. NELSON. Just one?

General WASHBOURNE. Well, it was one trouble, yes, and I will tell you about it.

We had the fighters at Presque Isle, about 20 miles away. We had to do some pavement work at Presque Isle and the fighters needed

somewhere else to operate. So we got permission from the Strategic Air Command to take the fighters over to Limestone and keep them there for 2 or 3 months while the Presque Isle pavement work was being done. After they had been over at Limestone about 2 weeks, we had a pretty urgent call from the base commander to get those fighters off his place. They were taking up his apron. We sent people in to see what the trouble was and found that the fighters were dripping fuel around on the asphalt apron and leaving a series of footprints everywhere they stood.

I personally saw them. They were about 18 inches long and 6 or 8 inches wide and about three-quarters of an inch deep—just a flat depression where the fighters were standing. The cause of it was that the pavement was softened by the dripping and fuel spillage and the like by the fighters and when they sat there overnight with their weight they made these little depressions.

We told him that we couldn't get the fighters off his field. He would just have to keep moving them around on the apron so they didn't do too much local damage. After about 3 months they went on back to Presque Isle and I didn't hear any more about it.

Mr. NELSON. Any damage to the runway because of that?

General WASHBOURNE. I don't know of any damage to the runway that happened while they were there. Colonel Alexander reminds me that some of the ends of the runway were burnt, where they ran up on the takeoff. I didn't personally see it.

Mr. NELSON. How far in was that on the runway, could you tell me?

General WASHBOURNE. How——

Mr. NELSON. Was it within the thousand feet that you specified?

General WASHBOURNE. Yes, within the thousand feet.

Mr. NELSON. Well, since, you have operated B-47's and B-36's out of Limestone, haven't you?

General WASHBOURNE. B-47's have used Limestone for staging. They don't operate from there. I suppose there have probably been a couple of dozen landings—no, I would say maybe 200 landings of B-47's there.

Mr. NELSON. Any B-36's been operating there?

General WASHBOURNE. B-36's have been in there for about 6 months. I haven't heard of any difficulty with them.

Mr. NELSON. Now, General, I would like to have you explain for the committee, because I am all confused about it, how this 5 percent differential operates and how it was arrived at.

Genreal WASHBOURNE. Yes, sir, I would be glad to.

We have about $150 million worth of pavement to be awarded in 1954 and prior years' work. That has been authorized and funded beginning 1950 and we haven't got it built yet.

We also have coming up in the 1955 program, in building up from 120 wings, something on the order of $200 million worth of pavement. There will probably be even more in 1956 and maybe even some after that. But that is the basic nature of the problem.

We were unwilling to disregard the mounting trouble with asphalt in critical areas, in putting that pavement under construction. It didn't seem right to us just to disregard these things and go ahead and put it in on a first cost basis without having enough experience in jet operations to be sure.

There seemed to be a good deal of merit in this alternate bidding, so that the contractor would have a chance to have full competition on the bidding.

What we would like to do is to obtain alternate bids and then shop the bid prices. In other words, if the concrete can be furnished at a very low cost over and above the low bid on asphalt, we would like to be able to just take it.

On the other hand, if the spread is appreciable, we would not think it was worth it, maybe.

Mr. NELSON. Well, you have been shopping the bids in 2 or 3 instances, haven't you?

General WASHBOURNE. Well, in a few instances. Your ability to do that depends upon the wording of the contracting officer's invitation.

Now, we had a conference with the construction agencies early last fall, as we have several times on this problem, and they very strongly objected to a practice of taking alternate bids without telling the bidders in advance what the basis of award would be.

Mr. RIVERS. That is the only thing to do to start with.

General WASHBOURNE. Well, Mr. Rivers, shopping the bids with the decision to be made by the contracting officer after they are in is a very difficult situation. In the first place, the contractors feel that their bid doesn't stand on its merits but is subject to interpretation and evaluation and the contracting officer feels that, well, he doesn't want to make the decision because there is a lot of money involved and he frequently just recommends what it ought to be and asks the Air Force or the Chief of Engineers or somebody to underwrite what he thinks ought to be done.

That situation is strongly objected to by the General Accounting Office and they have indicated they wanted no part of that kind of handling of Government work.

Mr. RIVERS. Well, let's take an "X" case——

Mr. HESS. Just a minute, Mr. Rivers. Mr. Nelson has the witness.

Mr. RIVERS. Oh, yes, excuse me.

Mr. NELSON. I yield to the gentleman.

Mr. HESS. Okay, he yields to you.

General WASHBOURNE. So the result was the construction agencies agreed that they wanted no part of alternate bidding unless the Air Force was in a position to predetermine and prestate a difference—the basis of award.

Now, that left the problem up to the Air Force, then, of determining what, if any, difference there would be in terms of accepting those bids.

We feel that there is a preference for concrete that has been developed in the last year or two under jet operation. Our problem is we don't rightly know how much it is worth yet.

The difficulty was pointed up in connection with several bids. For instance, out at Smokey Hill about 2 years ago we got alternate bids on about a million-and-a-half-dollar job and the difference between asphalt and concrete was $900. We, of course, had no difficulty in taking the concrete bid for the $900 difference.

At several places, the concrete bidders came in with a very small difference in the bid, but the terms of the invitation did not allow the Government to take any except the low dollar bid. So that no matter

if concrete had been available at just a few dollars more, we would not have had that choice.

As I said, we would have preferred to shop the bids. But we can't do that under Government bidding procedures. So we were confronted with prestating a differential that we would pay in terms of a concrete bid if the competition turned out to be close.

Now, the question was, then, what differential should we state? We know, for instance, that if the 15 per cent is the difference between taking alternate bids and not taking alternate bids, 40, 50, or 60 percent of the jobs won't fall within that bracket anyway and so they are out. Having got alternate bids within the 15-percent spread, we found that a 10-percent premium would probably mean an area of maybe $9 million in the $150 million that we have in 1954 and prior years' programs that would be affected.

I should say, estimating the $200 million in 1955 might affect an area of $15 million. So that there was a very small proportion of the total program that was involved in the decision regarding 10 percent or 5 percent or any other percentage that was within reason.

I would say——

Mr. NELSON. General, could I interrupt you?

General WASHBOURNE. Yes, indeed.

Mr. NELSON. Then the Air Force policy is to determine itself whether or not there is a 15 percent or less differential between concrete and asphalt? That is the first step?

General WASHBOURNE. We ask the construction people to make that determination. They do the engineering and estimating.

Mr. NELSON. And then having made that determination, it is up to the Air Force or the Air Force can elect whether to submit alternate bids or whether to say just this shall be concrete, is that correct?

General WASHBOURNE. Well, Mr. Nelson, my difficulty is this, that we don't do this work directly and we have to give the construction agencies a procedure for them to work on.

Mr. NELSON. Yes; but is that the basis of the policy you issued to the construction people?

General WASHBOURNE. Yes, it is. In other words, we figured that if the engineer estimates, the Government estimates were close, that we owed it to ourselves to get alternate bids to see just how close it is.

As I say, I have to do that by means of directives, setting up a procedure that the 50 or 60 district engineers can follow without phoning into Washington every time they want to do something.

Mr. NELSON. Then your policy is that if this estimate made by the construction people shows that the difference is 15 percent or less, you always ask for alternate bids?

General WASHBOURNE. Not always. There are many cases of course, where alternate bids are not proper and some in which they have been waived by other directives. But generally that is the case, that if the spread is 15 percent or less on the Government estimate the construction agency asks alternate bids.

Mr. NELSON. Then after you have asked for alternate bids, this 5 percent differential comes into effect; is that right?

General WASHBOURNE. Yes. In the invitation for the alternate bid, he prestates that if the all concrete project, the whole project, is

bid in all concrete at 5 percent or less above the bid in the combination of asphalt and concrete, that he will award the concrete job. That is the nature of this directive which we have put out.

Mr. NELSON. Well, does that directive indicate that it is the opinion of the Air Force that concrete—the present opinion of the Air Force, subject to change as they get more experience—that concrete has one-twentieth more the longevity, has one-twentieth less in maintenance, and one-twentieth better than asphalt, is that right?

General WASHBOURNE. It doesn't say that, Mr. Nelson, but I guess you might say that is the nature of the conclusion which would lie behind it.

Mr. NELSON. Well, that is the reason that you have this 5 percent differential?

General WASHBOURNE. Yes, that is the nature of the reason; yes, that is right.

Mr. NELSON. Now, who was the gentleman yesterday that testified, the engineer?

General WASHBOURNE. Mr. Ferry, are you referring to?

Mr. NELSON. Mr. Ferry, yes. He said that in arriving at this 5 percent differential you just took the pavement contract; is that right?

General WASHBOURNE. The pavement project. You see, Mr. Nelson, the contracting officer determines the manner in which he will group the several projects on a base for advertisement. Whenever he groups the airfield pavements and earthwork and all that stuff up into one grouping and advertises it as one job, that is what we are talking about.

Mr. NELSON. Well now, General, as I indicated yesterday—I want to ask you about Plattsburg.

General WASHBOURNE. Yes.

Mr. NELSON. I want to ask you about that, because the figures which I have show that in the bid on pavement alone the difference between asphalt and concrete was 12.3 percent, and they indicate that something else must have been added into the contract to get it below 5 percent. I would like to find out what the facts are.

General WASHBOURNE. I will ask Mr. McCloud to read the information on that job, Mr. Nelson.

Mr. MCCLOUD. Plattsburg when it was awarded or was put out to bid was grouped into three separate schedules, involving similar types of work. Schedule 1 included all grading, all drainage, all earthwork, all paving, and the railroad relocation, that all being a similar type of work.

Mr. NELSON. What was the bid price?

Mr. MCCLOUD. I don't have the exact bid prices. But the differential between the 2 low bids, 1 on all-concrete and 1 on the asphalt-concrete combination, was 4.7 percent.

Mr. NELSON. And that included grading and drainage and earthwork and paving, and what else?

Mr. MCCLOUD. And the railroad.

Mr. NELSON. What did the railroad have to do with paving?

Mr. MCCLOUD. That is a similar type of work to airfield, road and railroad construction, being all considered similar types of work.

Mr. NELSON. That was relocating a railroad?

Mr. McCloud. Yes, sir.

Mr. Nelson. What has that to do with the cost as between asphalt and concrete?

Mr. McCloud. It was in the bid and it could not be taken out. In order to take the low bid, it was on one schedule and it was on an all-or-none basis.

Mr. Nelson. Well, what was your bid on asphalt for noncritical concrete?

Mr. McCloud. We do not have that figure available.

Mr. Nelson. Could you furnish it?

Mr. McCloud. Yes, sir, we are getting that now.

Mr. Nelson. And would you also give me the bid for concrete on critical and noncritical? And what was the bid price for relocating the railroad?

Mr. McCloud. I will furnish that also.

(The following was furnished later for insertion at this point.)

Pavement Bids, Plattsburg Air Force Base

1. Bids were received for the construction of pavements at Plattsburg Air Force Base on December 23, 1953. Practically the entire fiscal year 1953 program was advertised under three separate schedules in which comparable types of work were grouped together as follows:

Schedule I. All work involved in the development of the airfield.

Schedule II. All work involved in the construction of the POL system.

Schedule III. Construction of buildings and supporting utilities.

2. Schedule I included all airfield pavements and breaks down into the following line items of work with the low bid on the basic schedule and concrete alternate shown:

Basic low bid, concrete and asphalt construction	$8,670,292.10
Alternate low bid, all concrete	9,089,109.90

3. The total of schedule I comprised over 100 items of individual work and included all grading, drainage, subgrade, and paving for the runway taxiway and apron system, plus airfield lighting and grid duct system in the apron. In addition it includes all grading and drainage work in connection with relocation of a railroad and a few small buildings which must be removed in order to construct the airfield. The work is, therefore, considered to be so closely related that it is not feasible to split the contract.

4. The difference in the two low bids, as shown above, is $418,817.80 or 4.8 percent. Since the cost differential was less than 5 percent the award was made after January 8, 1954, to the low bidder on the alternate all-concrete bid. The total area of the airfield pavement is 895,889 square yards.

Pavement Bids, Portsmouth Air Force Base

1. The invitation for bids for the pavements at Portsmouth Air Force Base was issued in December 1953, with an opening date after January 8, 1954. A change by addendum was therefore made in the advertisement to bring this project within the provisions of the January 8 pavement policy. Bids have now been received and the results are as follows:

(*a*) Low bid all-concrete pavement	$10,375,005
(*b*) Low bid concrete-and-asphalt combination	9,769,086

2. The difference between the two bids is $605,919, or 6.72 percent. Since this differential exceeded 5 percent, decision has been made to make the award on the basis of the concrete-asphalt combination. This work included all grading, drainage, subgrade preparation, and paving. Total area involved is 1,181,733 square yards.

PAVEMENT BIDS, HANSCOM AIR FORCE BASE

1. Hanscom Air Force Base was one of the jet bases selected in 1952 to be constructed in the apron area with a tar-rubber wearing course. This material has proven to have considerable promise as an economical jet resistant surface and the Air Force is using this material to a limited extent in representative locations to test its merit under normal operating conditions.

2. The invitation for bids for Hanscom pavements consisting of a runway and taxiway extensions and apron construction was not advertised for bids until after January 8, 1954. Since the new policy had been published, an estimate was made by the New England Division engineer on all concrete versus flexible pavement in the noncritical areas, with results as follows:

(*a*) Tar-rubber apron, concrete runway end warmup pad, asphalt runway, and taxiway	$1,384,000
(*b*) Tar-rubber apron, concrete runway, and taxiway and warmup pad	1,869,000
(*c*) Tar-rubber apron and runway end and warmup pad, asphalt runway, and taxiway	1,414,000

Estimated cost differentials:
(*b*) versus (*a*)=35 percent more
(*c*) versus (*a*)=2.16 percent more
(*b*) versus (*c*)=32 percent more

3. From the above, it is obvious that the all concrete construction is too expensive in this location. Since the apron had already been specified for tar-rubber construction, it was decided to invite bids on the basis of tar-rubber in all critical areas. This extended this construction to include the end of the runway extension and warmup pad (2 (*c*) above). The project is advertised for bids to be received on February 25, 1954. The area involved is 83,000 square yards of tar-rubber wearing course and 41,500 square yards of asphalt.

PAVEMENT BIDS, SMOKY HILL AIR FORCE BASE

1. In January 1951 bids were received for construction of 200,000 square yards of apron at Smoky Hill Air Force Base. This was before the publication of the first pavement policy in August 1952, and consequently alternate bids were taken since past experience had indicated that concrete could compete with asphalt in this particular area. Results of the bids received are:

(*a*) Low asphalt bid	$2,048,985
(*b*) Low concrete bid	2,049,858

2. Since the difference in cost was only $873, the concrete bid was accepted.

PAVEMENT BIDS, MCGHEE-TYSON AIRPORT

1. Bids were received on June 28, 1951, for construction of 130,000 square yards of runway extension and apron at McGhee-Tyson Municipal Airport at Knoxville, Tenn. The Air Force pavement policy regarding designation of critical areas was not in force at this time, and the alternate bids were taken on all asphalt versus all cement. Results of this bid opening are:

(*a*) Low concrete bid	$2,202,704.05
(*b*) Low asphalt bid	2,064,735.15

2. The difference in the two bids is $137,968.90 or 6.7 percent. The contract was awarded on the basis of the low asphalt bid. After award of this contract the city of Knoxville and chamber of commerce of that city interceded and offered to underwrite the cost differential in order to get concrete pavement at this municipal airport. The offer was accepted and a change order was issued to the contractor who was low bidder on both alternates. The type of pavement was then changed and is now completed.

3. The unusually high price for this work is justified because of the heavy grading including rock excavation involved in making the runway extension. Knoxville is located near the western slope of the Appalachian Mountains making airfield construction very expensive.

Mr. NELSON. You do know the bid price for relocating the railroad, or was it all lumped together? Wasn't it itemized?

Mr. MCCLOUD. It was itemized in the abstract of bids, which we do not have. They are in the district office.

Mr. NELSON. Do you know what the difference in bid price would be as between asphalt on the runways and concrete on the critical areas and concrete on the runways and the critical areas?

Mr. MCCLOUD. No, sir; not at this point, we do not. We have asked for that information. It is out in the field.

Mr. NELSON. Well, would you break that down for me? Do you understand what I want?

Mr. MCCLOUD. Yes, sir.

Mr. NELSON. Could you tell the committee how much higher the bidding was for concrete on the critical areas as against asphalt?

General WASHBOURNE. Mr. Nelson, I don't believe the contractors were allowed to bid asphalt on the critical areas. I doubt if that information would be developed.

Mr. MCCLOUD. That was not taken.

General WASHBOURNE. That I think is the position——

Mr. NELSON. General, I want to say this to you, that in the brief filed by the Asphalt Institute—I believe you have a copy, don't you?

General WASHBOURNE. I have seen a copy; yes, sir.

Mr. NELSON. You will find that the bid price for asphalt is given contrasted with the bid price for concrete and the bid price for concrete was 69 percent higher.

General WASHBOURNE. Mr. Nelson, I can't speak for what information the Asphalt Institute submitted, but I positively know that the district engineer can't accept bidding for asphalt pavement on these critical areas of Air Force permanent bases. I am fairly sure that would have to be a conjecture of what they might have bid.

Mr. NELSON. Would you do this for me, General: Do you have a copy of the brief submitted by the Asphalt Institute?

General WASHBOURNE. I can get hold of them.

Mr. NELSON. Will you check the figures on Plattsburg Air Base and let me know?

General WASHBOURNE. Yes. There is no question, Mr. Nelson, if they could have bid all asphalt on the entire paving project at Plattsburg, that there would have been a considerable dollar difference.

Mr. NELSON. Well, I understand that, General.

General WASHBOURNE. Yes, sir.

Mr. NELSON. The thing I am objecting to right now is at Plattsburg particularly you did not compare the prices for pavements. You brought a railroad in.

General WASHBOURNE. Well, there is logic in that. The construction of any large pavement area involves a great deal more than just the type of skin that you put on top of the job. When a contractor goes in to grade one of these big airfields of, oh, a couple thousand acres, he has to move a lot of earth from one place to another over several other places. If a railroad embankment or drainage or any of that sort of thing is involved, there is a lot of money riding on where he puts the cut and fill.

Mr. NELSON. Yes, I see your logic, General.

General WASHBOURNE. Yes, sir.

Mr. NELSON. But my point is this: It isn't fair to compare as between asphalt and concrete and including a railroad in.

General WASHBOURNE. Well, we have to defend the district engineer's judgment in grouping his projects that way because of the very considerable amount of money that was involved in earth work at Plattsburg.

Mr. NELSON. I haven't had any objection to your doing that at all, General. What I am saying in effectuating the Air Force policy of a 5-percent differential you should compare the bid on macadam and the bid on concrete and not bring the railroad in.

General WASHBOURNE. Well, we do that, of course, by allowing the district engineer to advertise a pavement project. That is why this 5 percent, of course, does make a difference. We will miss some of them. We will miss a lot of these jobs on that 5 percent. For instance, I believe Portsmouth has been advertised and awarded on the basis of combination pavement because the difference turned out to be 6 percent. So we lose a job there for concrete that I am sure the using command would very much like to have had. It is the same type of field exactly as Plattsburg, a mate to it in fact. We get one and lose the other on 5 percent. If we would set 6 or 7, we would have probably gotten both of them. If we would have set 4 percent we would have lost both of them. That is how close it is.

Mr. HÉBERT. Excuse me. May I ask a question, Mr. Chairman?

Mr. HESS. Yes.

Mr. HÉBERT. What do you mean, General, by losing? Are you out to get something?

General WASHBOURNE. Yes, sir. The expression "lose" means we prefer concrete and we are willing to pay the premium to get the contract and when we set a factor that just misses getting concrete for a small amount of difference——

Mr. HESS. You can change your factor any way you see fit, then, in order to get your contract?

General WASHBOURNE. Well, it is not lightly done, Mr. Hess, but I believe the Air Force is the one to do it based on operational requirements.

Mr. HÉBERT. In other words, you are like the little boy in school who looked in the back of his mathematics book to find the answer and then worked from there?

General WASHBOURNE. No, sir, not at all.

Mr. HÉBERT. May I finish?

General WASHBOURNE. Yes, sir.

Mr. HÉBERT. You put down and say "we want concrete." Then you do your best to find out how you can justify concrete. How hard did you have to fight not to get concrete on this Florida base?

General WASHBOURNE. Well. I personally favored doing it. I can also inform the committee that the using command which was Strategic Air Command, involving General LeMay's opinions, opposed the use of asphalt on Homestead for any of the pavement. They particularly wanted us to follow the criteria which would require concrete on the critical areas. That would be about three-fourths of the million or so yards at Homestead.

Mr. HÉBERT. And no matter how hard you manipulated the figures and no matter how hard you tried to come up with the answer, you couldn't come up with an answer and you had to finally give in?

General WASHBOURNE. It was not a difficult decision at all, Mr. Hébert. The material underlying the soil at Homestead is coral. Now, the engineers in designing pavements get full value of that coral under a flexible pavement. But in designing concrete to go over the coral you can't take advantage of that rigid base and have to design the thickness of the slab the same as if it were a much inferior material.

That engineering estimate ran on the order of $3 million difference in favor of asphalt.

Mr. HÉBERT. Well, now, would this be fair—just one more question, Mr. Nelson, please. Would this be fair, to say, that the Air Force's attitude is simply this: "We want concrete. Now we will do anything that we can do to justify getting that concrete and the only time we are not going to take concrete is when we are caught in the switches and can't come up with a flexible figure that looks pretty good"?

General WASHBOURNE. No, sir, I can't agree with that situation, Mr. Hébert.

Mr. HÉBERT. Well, here you tell me at Homestead, in Florida, that everybody from General LeMay down wanted concrete.

General WASHBOURNE. No, sir, I don't believe I said it that way.

Mr. HÉBERT. How did you say it?

General WASHBOURNE. I said General LeMay wanted concrete, but I could not see concrete. The Air Staff could not see concrete. The engineers recommended against concrete. So we did not build it in concrete.

Mr. HÉBERT. That was against——

General WASHBOURNE. Because of the extreme difference in cost between the two types of pavement.

Mr. HÉBERT. Well, wasn't there a figure introduced here where some two or three million dollars was the deciding factor on another job and you waived that aside and took the concrete which was more expensive?

General WASHBOURNE. Not to my knowledge.

Mr. HÉBERT. Mr. Nelson, do you recall? You had that figure here the other day and I think you used it.

Mr. NELSON. I don't recall it.

General WASHBOURNE. I believe the Asphalt Institute——

Mr. HÉBERT. It was the Plattsburg case.

General WASHBOURNE. Yes. I believe the Asphalt Institute submittal contains such figures if they bid the whole job in asphalt, but, of course, that is not within our criteria. It is a conjecture.

Mr. HÉBERT. All right.

Mr. RIVERS. Will Mr. Nelson yield, Mr. Chairman?

Mr. HESS. Will the gentleman yield to the gentleman from South Carolina?

Mr. NELSON. I would be glad to yield.

Mr. RIVERS. I just wanted to follow up what Mr. Hébert said. I have a note here.

General, first of all, I don't think the Strategic Air Command would ever want asphalt, due to the tremendous weight of the bombers and those that are coming. Is that true or not? I am speaking about General LeMay.

General WASHBOURNE. I believe General LeMay is just as cost conscious as any of our commanders——

Mr. RIVERS. I am not speaking about that. I am speaking of the safety factor.

General WASHBOURNE. From the standpoint of safety and general suitability, there is no question that he would prefer concrete pavement.

Mr. RIVERS. Now, if you didn't have economy to effect, if the dollar were no item, would you ever construct asphalt, taking into consideration—I am not trying to trap you on the question—the longevity of it and the durability, the disintegration and the replacement, over a period of X number of years?

General WASHBOURNE. If dollars were not a factor in this problem we would take concrete in the Air Force every time we had a project.

Mr. RIVERS. And the reason for that is—may I interpolate—because you can build it to take care of the foreseeable weight of planes for the future?

General WASHBOURNE. That is one of the major reasons why we have that preference, yes.

Mr. RIVERS. Is there any kind of an asphalt that would compare in durability for a certain period of time with that of concrete?

General WASHBOURNE. I think that is a laboratory possibility, Congressman, but I don't know that it has a practical application at this time. It may come to that.

Mr. RIVERS. At this time, is there? I say at this time.

General WASHBOURNE. No, sir. We still have to take the pavements as the contractors build them and deliver them to us and I don't think they are that good yet.

Mr. RIVERS. I see.

Mr. NELSON. General, this is the first time I have heard you complain about weight on the runway. Your major complaint so far has been due to blast and spillage. Now tell me about weight on an asphalt runway as contrasted with concrete.

General WASHBOURNE. Well, Mr. Nelson, I believe the reference to weight was made by Congressman Rivers, not by me.

Mr. NELSON. Yes, but you gave him an affirmative answer.

General WASHBOURNE. Well, it is a factor in designing pavements. We have gradually increased the size of Air Force craft to the 400,000 pound range already. Some of our research people have indicated that we were not far away from a 500,000 pound aircraft for many purposes, including bombers and transports. That increase in weight doesn't affect pavement until you start wondering what kind of undercarriage is going to be on the aircraft. That is where the problem originates.

If we have enough wheels and big enough tires, it won't affect the heavy duty criteria that we are using now.

But to put that kind of an undercarriage on a big airplane, of course, lowers its performance and costs you fuel and performance. So the designers have a problem of making an airplane that it good to fly and yet can be handled on the ground. And the pavements, of course, come into the picture immediately.

Mr. NELSON. Well, you have the same trouble with both pavements, don't you? They have to be designed to take care of that kind of an airplane.

General WASHBOURNE. That is correct.

Mr. NELSON. And if they are designed to take care of that airplane, each one of them is suitable except for blast damage and fuel spillage.

General WASHBOURNE. As far as I know the flexible pavement and the rigid pavement can both be designed to carry the weight, whatever it turns out to be.

Mr. NELSON. But a concrete pavement that isn't built for that type of plane is just as inadequate as an asphalt pavement.

General WASHBOURNE. Sure, it will break up. The problem is: Can we find a suitable gear design to carry these heavy weights on the pavements that we are building now or have to build in the immediate future to fly for the next 30 years?

Mr. NELSON. Well, now, General, what do you propose to do with fields like Limestone and Thule that are already built of all asphalt? Are you going to ask us for money to put in concrete aprons in critical areas?

General WASHBOURNE. I don't propose to at the present time. Those are built and they are in operation and I think that is part of the problem that has just to work itself out over the next few years.

Mr. NELSON. Well, now, in this business of shopping bids, isn't it true that in a great many instances now you are asking a contractor who has been low bidder on the basis of asphalt to resubmit on the basis of concrete?

General WASHBOURNE. Would you state that again, Mr. Nelson?

Mr. NELSON. Isn't it true in some instances now, where you have a low bid on the basis of asphalt in noncritical areas, that you have asked the particular contractor to resubmit on the basis of concrete?

General WASHBOURNE. I know of 2 instances where that has been done in the last 3 months.

Mr. NELSON. One is at Dow Field in Maine.

General WASHBOURNE. I didn't know if that has been done at Dow. I don't think so. The two I was about to mention are Abilene Air Force Base, in Texas, and Webb Air Force Base, also in Texas, at Big Spring.

The bid at Abilene was about 3½ percent, I believe, in favor of the combination. And we asked the contractor what kind of money he would want to do it in all concrete. When he told us, we said, "Never mind."

Mr. NELSON. What was the difference?

General WASHBOURNE. Oh, I think it was around $500,000 in 5 million, something like that, around 10 percent.

At Webb Air Force Base, before this new criteria was issued, we had an apron awarded there, right next door to a concrete apron. It was an asphalt apron. It was adjacent to a concrete apron on one side and a concrete wash rack on the other. We asked the contractor what the cost would be to change the character of that to concrete and I think he told me it would cost about $100,000 more to put it in concrete than it would in the black top.

I don't know that there has been any decision on that. I can't even remember much more about it than just the fact that we did look into it.

Mr. NELSON. That is all I have, Mr. Chairman.

Mr. HESS. Any questions by any of the other members?

Mr. COURTNEY. May I ask a few questions, Mr. Chairman?

Mr. HESS. Mr. Courtney.

Mr. COURTNEY. General, to clear the record, in the Air Force's presentation, there is the statement that before you submit a bid with alternates, concrete as against asphalt, that you first make an engineer's estimate. Costs of one against the other.

General WASHBOURNE. The construction agency makes it, Mr. Courtney.

Mr. COURTNEY. Well the construction agency, yes.

General WASHBOURNE. Yes.

Mr. COURTNEY. And that if the differential is within a 15-percent bracket, in other words, if concrete is 100, to pick a figure, and asphalt is 85, then in that case there is no alternate but you bid concrete; is that right?

General WASHBOURNE. Usually the other way around. If the spread is more than 15 percent, we advertise in accordance with the critical and noncritical areas and take the combination. I mean 100 percent concrete is out the window right at that point.

Mr. COURTNEY. Well, let me see if I understand correctly for this record.

General WASHBOURNE. Yes, sir.

Mr. COURTNEY. Which will be used afterward.

First of all, how much of a tolerance or how much of a percentage of error would you allow in making an estimate and still consider it a reasonable estimate of cost?

General WASHBOURNE. Well, to give you a flat figure, I would say about 5 percent.

Mr. COURTNEY. Roughly about 5 percent?

General WASHBOURNE. Yes. I don't think our people in estimating pavements think they are any better than that.

Mr. COURTNEY. Well, that view would be considered to be a normal, competent, and sufficient estimate with that amount of tolerance?

General WASHBOURNE. I think that is about as good as you would ever get. It is my experience that we get bids anywhere within 25 percent of the Government estimate and the Government estimate people think they are just about right.

Mr. COURTNEY. That is exactly what I am coming to, General. Now if you allow an estimate variation of 5 percent in concrete in making your determination before letting out the bid and a similar estimate for asphalt based on the information you have and if you allow a 15 percent differential, actually if you add 5 percent to the top estimate and 5 percent to the lower estimate you get a spread of 25 percent, don't you, before you actually determine whether or not you will let for asphalt?

General WASHBOURNE. No, it doesn't work that way, Mr. Courtney.

Mr. COURTNEY. How does it work, precisely?

General WASHBOURNE. I think it works this way, at least that is the way we figured it would work, that the area in which we wanted to get competitive bidding was 10 percent and——

Mr. COURTNEY. I am talking about, General, if you please, total figures.

General WASHBOURNE. That is right.

Mr. COURTNEY. Total figures, rather than area figures.

General WASHBOURNE. The job, 10 percent.

Now allowing a 5 percent additional area in which the Government estimate might be wrong, that led us to saying to the construction

agencies, "If your estimates are within 15 percent of each other, let's give the contractors a chance to lay it on the line and then we will know exactly what the difference is."

Mr. COURTNEY. But if they are less than 15 percent, then what happens?

General WASHBOURNE. It is 15 percent or less in which we have asked that alternate bids be taken.

Mr. COURTNEY. But if you take the maximum 15 percent spread and if you add the tolerance to each of the two estimates you get a total spread of 25 percent.

General WASHBOURNE. I don't follow that at all, Mr. Courtney.

Mr. COURTNEY. Well, what is the fact, so the record will be clear on it?

General WASHBOURNE. Well, the facts for the record are that we would like to get competition within an area where the Government estimate thinks there is up to 10 percent difference in the two types of pavement. Allowing for errors in estimating, we think that a 15 percent area is reasonable within which to spend the money to get alternate designs and take alternate bids. It costs some money to take alternate bids and we don't want to spend it in cases where there isn't any point.

Now that is the area in which we think there is a return on it.

Mr. COURTNEY. Well, then, do you say that the 15 percent spread takes or considers the tolerance allowable on the high and the low estimate? Is that what you are trying to say?

General WASHBOURNE. Yes, that is right, it does.

We find that we may estimate that the difference in jobs, for instance, would be 14½ percent and a contractor can come along and make monkeys out of the estimators by bidding a 3 percent difference, the same contractor. That is the situation we have to take into consideration in setting up a procedure that will cover this entire problem.

Mr. COURTNEY. Now that determination, then, is made before you call for bids?

General WASHBOURNE. The Government estimates are made before, yes.

Mr. COURTNEY. What is the paving at Hickam Field?

General WASHBOURNE. There is a mixture of apron there. There is some asphalt and some concrete at Hickam.

Mr. COURTNEY. Now about the ends of the runways at Hickam?

General WASHBOURNE. I am told they are asphalt. I don't personally know.

Mr. COURTNEY. They are all asphalt.

Now do you have damage reports from jets on Hickam Field?

General WASHBOURNE. I don't think so. There probably have been local repairs made, but I don't have any major repairs or formal complaints there.

There very probably will be fewer nonjets go through, because that is pretty well offshore.

Mr. COURTNEY. Well, now, let me take Iceland, Keflavik, Iceland. What is the pavement there and what damage reports have you had on that?

General WASHBOURNE. That is all asphalt, I am told.

Mr. COURTNEY. It is 100 percent asphalt.

General WASHBOURNE. I think so. I was there a few weeks ago and I didn't see anything but asphalt. I believe that is right.

Mr. COURTNEY. And that is heavily used by jets?

General WASHBOURNE. Well, it is just being finished. It will be heavily used by jets.

Mr. COURTNEY. And do you have any damage reports from Keflavik?

General WASHBOURNE. No. It is just being completed.

Mr. COURTNEY. What about Thule? I think you said Thule——

General WASHBOURNE. Thule is an asphalt runway. I believe the aprons are also asphalt. There has been jet squadron in there for several months. I haven't heard any particular trouble one way or the other.

Mr. COURTNEY. Now what about the two fields in the Azores?

General WASHBOURNE. Mr. Courtney, it is my recollection that the field at Santa Maria in the Azores is asphalt and that the overlay being placed on the big field at Lajes are asphalt. Some of the existing apron at Lajes, if I remember correctly, is concrete, and the big Strategic Air Command apron in the triangle area is also probably going to be concrete.

Mr. COURTNEY. That is not completed yet?

General WASHBOURNE. No, it isn't built.

Mr. COURTNEY. They are not built. But what about the damage reports on those fields?

General WASHBOURNE. I don't think we have had any damage reports on them either way, Mr. Courtney.

Mr. COURTNEY. Those fields are of course, used by jet?

General WASHBOURNE. No. Except for an occasional B–36 that might turn on his jet pods for take-off, I doubt if they have seen any jet use there.

Mr. COURTNEY. In presenting your damage reports—I have forgotten whether the question was addressed to you or Mr. Ferry, or General Ramey, I guess the damage reports on these various fields which you say point up the advantages of concrete as against asphalt or combinations of asphalt, will you make particular reference to these four fields?

General WASHBOURNE. That is Thule——

Mr. COURTNEY. Keflavik, Thule, the Azores, and Hickam.

General WASHBOURNE. And Hickam. Well, yes.

(The following was later received by General Washbourne for insertion at this point.)

No reports of damage from fuel spillage or blast have been received concerning Thule, Keflavik, Azores, and Hickam. As jet aircraft operations increase at these installations there is no reason to believe that complaints will not be received. However, there has been considerable expense involved in leveling the runway pavements at Keflavik. Following World War II the elements have taken their toll and the pavement surfaces have become extremely rough. A smooth asphaltic surface is being applied so as to provide safe jet-fighter operations.

Mr. NELSON. Mr. Chairman.

Mr. HESS. Mr. Nelson.

Mr. NELSON. General, what was the date of your directive that specified that only concrete could be used in critical areas?

General WASHBOURNE. There were two, Mr. Nelson. In August 1952, we issued a directive about critical areas on airfields and that

designated certain areas as critical and others that could be built either way.

On January 8, 1954, there was an additional directive issued which expanded the requirements of the critical areas and set up this predetermination of bidding.

Mr. NELSON. Do you have any figures which would show this committee what has happened to the bid price of concrete per square yard in critical areas since you issued your directive? Do you know whether it has gone up or down or stayed the same?

General WASHBOURNE. I don't believe there have been any major projects bid since January 8, except Portsmouth and Plattsburg which have been discussed.

Generally, our records show that where both surfaces can be bid under the alternate bidding procedure——

Mr. NELSON. I am not getting at that, General. I asked you about the bid price on concrete per square yard in critical areas since you made your directive in August of 1952. They can't both be bid, can they, the critical areas? It is only concrete.

General WASHBOURNE. I can answer that by citing four different types of pavement bids, Mr. Nelson. It will be a little lengthy, but I think I better do it this way.

We start out with a record of heavy flexible pavement at Dover in December 1952, at $6.93 a yard——

Mr. NELSON. Is that asphalt or concrete?

General WASHBOURNE. This is flexible. I want to make the comparison. If you want to limit it to concrete——

Mr. NELSON. Yes.

General WASHBOURNE. Excuse me.

Mr. NELSON. Well, General, this is what I want. I want to find out: On August 1, 1952, you issued a directive which said that concrete only could be used in certain critical areas, did you not?

General WASHBOURNE. Yes; that is right.

Mr. NELSON. And you since then have had numerous bid prices on concrete for critical areas?

General WASHBOURNE. Yes, sir.

Mr. NELSON. I want to know what has happened to the price of concrete as bid for those critical areas per square yard since you issued the directive.

General WASHBOURNE. Generally, it has gone down right along, Mr. Nelson. The individual projects show a wide variation between bid prices on concrete. I could cite one at Lincoln, Nebr., in October 1952, where it went for $10.02 a yard, one at Brooklyn Field in December of '52 at $8.68 a yard, one at Barksdale in August of '53 at $7.27, a big job at Larson in August of '53 at $7.30, and one at Kirtland Air Force Base in May of '53 at $9.02.

By contract, throughout that same period, I can cite jobs that went, one at Travis Air Force Base in July of '53 that went for $29 a yard. There was also——

Mr. NELSON. Travis was due to the expense of haulage?

General WASHBOURNE. No, there was a special drainage problem there, Mr. Nelson.

There were at the same time jobs at Carswell at $12, jobs at Travis at $10, jobs at McGuire at $10.66. The lowest price for heavy rigid

pavement that I have shown here is $7.30. The highest cost per yard is the one at Travis of $29.66.

There is no patern at all to those prices as being before or after August 1952.

Mr. NELSON. Are these prices that you have cited me, General, only for concrete in the critical areas or are they the whole concrete bid?

General WASHBOURNE. Well, they are the all-concrete bids. They are primarily in the critical areas because at that time the asphalt was acceptable in the noncritical areas. It was usually low. That is the way it came in. I have some light rigid pavement figures which I think might be also interesting in showing that there is no pattern as to an average cost or no pattern as to the time.

In August 1952, the month that directive came out, we had a job at McClellan Air Force Base, near Sacramento, Calif., at $7.71 for light rigid pavement. We had a job at Grandview, Mo., in December of '52 at $10.53. In the same month, we had a job in Lochburn at $8.18 and one near Nashville, Tenn., at $5.88.

Mr. RIVERS. That is concrete?

General WASHBOURNE. Yes.

Mr. RIVERS. That is right out of the mills.

General WASHBOURNE. That is right. In September 1953, we had two jobs at Bryan, Tex., that went for $4.43 one time and $8.75 on another bid, in the same month.

I believe the highest bid we got for light pavement was at Sioux City, Iowa, in November of '52, at $14.97 a yard, and the lowest bid was the one at Bryan, Tex., in September of '53, at $4.43.

Mr. NELSON. General, suppose the Air Force, as you indicate you might like to do, should specify that nothing but concrete should be used in Air Force pavements, what do you expect would happen to the price of concrete?

General WASHBOURNE. I think the concrete people, contractors, would be smart enough to realize their competition had been lessened and they might take a few liberties with their bidding.

Mr. NELSON. Competition had been lessened? They wouldn't have any, would they?

General WASHBOURNE. Yes, sir.

Mr. HESS. Among themselves.

General WASHBOURNE. These contractors, Mr. Nelson, are in a position to offer you anything you want and among themselves they still have to go out and get these jobs. And I don't think the nature of the competition would result in materially different prices. But I have to agree with you that if the asphalt were completely out of the competition it wouldn't be quite as sharp.

Mr. NELSON. Well, you are speaking about the contractors. How about the cement industry? They can put a price on their product to the contractor.

General WASHBOURNE. Well, you have a point there. But still they have to sell the stuff and we have to use it.

Mr. HÉBERT. Mr. Chairman——

Mr. HESS. Are you finished?

Mr. NELSON. Yes.

Mr. HÉBERT. General, I just want one clarifying question, to ask you so it will be positive in the minds of the committee. I understand

you in defending the 5 percent differential, or preferential, of cement——

General WASHBOURNE. Yes?

Mr. HÉBERT. How did you arrive at that conclusion that 5 percent was a justifiable figure? I understood your testimony yesterday—I am refreshing my own memory—where you said you compared costs and made an exhaustive research and then came up with the 5 percent figure which was the proper figure after that examination and that survey and that you made the decision?

General WASHBOURNE. I didn't personally make it, Mr. Hébert.

Mr. HÉBERT. I mean how was the 5 percent chosen? Why did it say 5 percent? That was based on examination of previous experiences, costs, and so forth?

General WASHBOURNE. Yes, sir. There were several factors that went into it. One was an evaluation of how much more work we had to put in the ground. The other was how much of that work would be affected by any differential. The other was how much experience have we got to base it on? Another was what is the projection of jet operations in quantity and time? Another was the type of competition in the location of many of these pavement projects.

Another was the method in which we could implement any type of premium price. That involved procedures of governmental bidding.

Other factors were the opinions of the operating commanders, how strong they were and what type of operations they were based upon.

All those added up to a proposal from the Air Staff that a 10 percent figure was the proper one in which to try to express this preference for the concrete as opposed to flexible pavement.

That decision was staffed and argued back and forth over in the headquarters a good 4 months. It was finally decided, and the directive was issued, on the basis of the cutting it to 5 percent, with a 15 percent area on the Government estimates, as being the extent to which we felt justified in going at this time, based on the information.

Mr. HÉBERT. That is correct. In other words, it was a substantial study made, and the figure 5 percent was arrived at mathematically and after—it wasn't a figure that was picked out of the air or anything like that.

General WASHBOURNE. By no means. It wasn't proven as a figure because you can't prove things that haven't happened yet.

Mr. HÉBERT. That is right.

General WASHBOURNE. But it was our very considered estimate of the problem and what we could afford to do about it, all things considered.

Mr. HÉBERT. That is right. In other words, you all arrived at this conclusion based on your experience and it was not—in other words, you didn't just grab a figure out of the air and say 5 percent arbitrarily?

General WASHBOURNE. Well, I remember Mr. Ferry's reference to that yesterday morning, but I am sure he didn't mean it that way because he was a party to this problem all the way through.

Mr. HÉBERT. Let me read you what Mr. Ferry said on yesterday.

General WASHBOURNE. Yes, sir.

Mr. HÉBERT. I want it in the record at this point. [Reading:]

Mr. NELSON. How did the Air Force arrive at this 5 percent differential, Mr. Ferry?

Mr. FERRY. Our field commanders came in with a flat statement that they believed in their judgment that we would be warranted in paying a premium up to 10 percent and we sat around, some of the people who were responsible for that end of the business, and we said, "We think 10 percent is just too much. It just doesn't seem good judgment."

I may say parenthetically here for my own part, General, perhaps later on when you find you lost too many contracts under the 5 percent that when you get the 10 percent you won't lose as many.

General WASHBOURNE. Yes, sir; we recognize that.

So we arbitrarily, by "arbitrarily" I think I may have been the impelling factor, and we said, "Let's make it 5 percent."

Mr. NELSON. You picked 5 percent?

Mr. FERRY. Right out of the air.

That is on page 167 of yesterday's testimony. That is all, Mr. Chairman.

General WASHBOURNE. Mr. Hébert, I would like to comment on that at this point that Mr. Ferry and the civilian secretariat were not introduced into this problem from the beginning and Mr. Ferry has been with the Air Staff since about midsummer of last year and I don't think he meant at all to be flippant or anything like that. But the problem wasn't put up to him where he got his teeth in it until it was pretty well along in all these deliberations. And he may have given the committee an unfortunate impression that that was just tossed off the cuff. That is the furtherest thing from the truth.

Mr. HARDY. Mr. Chairman, strange as it may seem, I do not have any questions that I want to ask.

I did want to make an observation, however.

I have participated in a great many hearings on construction matters and I have had the privilege and the pleasure of interrogating a lot of witnesses, including a lot from the Air Force. And I want to say that I think General Washbourne has done a better job in presenting testimony on construction matters than any witness that I have ever had the pleasure of listening to and I want to compliment him for that.

General WASHBOURNE. I appreciate that, Mr. Hardy.

Mr. HARDY. I have to view with some skepticism some of the policies and procedures that he has adopted, but he has certainly been forthright and unequivocating in his answers and he has displayed a personal knowledge of the subject that he has to deal with which to me is most refreshing and encouraging. I just want the record to show that I am very grateful for having had the privilege of sitting in on this hearing and hearing him.

Mr. HESS. I can agree with you, Mr. Hardy.

General WASHBOURNE. Thank you, sir.

Mr. HESS. The gentleman has been forthright in giving us the answers that we asked for.

Mr. RIVERS. May I say, too, Mr. Chairman, that General Washbourne—I have noticed it in the big committee and I have heard it commented on—in never equivocating. Quite frequently the testimony is not exactly what we can agree with him on, but it is always to the point and we know it is sincere and we believe him. I think on one

occasion—I have seen only one other witness who has done it, and it was an Air Force general.

Mr. Vinson took 15 minutes of the committe to commend him. I think it is a good thing.

And, General Washbourne, you give the committee and certainly Mr. Hardy—Mr. Hardy is not an easy man to please. He makes darn few compliments to anybody, including himself. But I tell you that is a good thing to follow and it makes a good impression.

General WASHBOURNE. I appreciate that, Mr. Chairman. I feel that my responsibility in presenting the Air Force construction problems to the Armed Services Committee as a whole and to the various subcommittees is a very heavy responsibility. There is a lot of money riding on it and it is very important.

While I may be uninformed on many of these things, I will try to tell you how we look at it and of course it will be up to you to accept or reject what we propose.

Mr. HESS. That is all we ask, General, is for the representatives of the armed services to come up here and tell the truth and not try to beat around the bush and try to pull the wool over our eyes. We want to know what the facts are and I think you have made every effort to give them to us here. We appreciate it very much.

Thank you.

Mr. NELSON. Mr. Chairman, may I just say to the general that I hope he will give to the committee the information that we requested as soon as possible, so we may have that in making our determination.

General WASHBOURNE. Yes, sir; we will do that very fully, Mr. Nelson. There is a great volume of information that bears on this and some of your questions will be answered very fully. The volume of submittals in writing will be quite heavy.

Mr. HESS. Thank you very much, General.

General WASHBOURNE. Yes, sir.

Mr. COURTNEY. Mr. Chairman, the United States Rubber Co. and the Flintkote Co. have been invited to participate this morning. Their presentation is short and I think it might be appropriate at this time.

Mr. Chairman, on the committee's left is Mr. Chris Seibel, Jr., paving products manager, the Flintkote Co., and on his right is Mr. S. P. Tauber, sales representative, United States Rubber Co.

TESTIMONY OF CHRIS SEIBEL, JR., PAVING PRODUCTS MANAGER, FLINTKOTE CO., AND S. P. TAUBER, SALES REPRESENTATIVE, UNITED STATES RUBBER CO.

Mr. HESS. We will be very glad to hear you, gentlemen.

Mr. COURTNEY. Mr. Chairman, we have asked questions from time to time as to combinations and new developments in the art of paving, combination items of concrete or other substances, and these gentlemen have had some experience and desire to present their observations, particularly with reference to damage and cost.

Mr. SEIBEL. Before reading the prepared statement, Mr. Chairman, we would like to ask the committee's permission to make a short physical demonstration.

The committee asked yesterday what effect jet fuel has on asphaltic concrete and we believe that we can show this and are prepared to do so now.

Mr. HESS. Go right ahead, gentlemen.

Mr. SEIBEL. We have here with us a core which has been taken from the end of a runway on one of the Air Force bases that is now currently in operation and use. The pavement from which that core has been removed has never been subjected to jet fuel spillage.

We also have here a section of tar rubber pavement——

Mr. HESS. Is this something new?

Mr. SEIBEL. That is right.

Mr. HESS. Are they being used at the present time?

Mr. SEIBEL. If I might beg off, Mr. Chairman, we will explain that fully, but that is from the pavement in the field. That section has been cut from the pavement that has been subjected to 200 cycles of fuel spillage.

Mr. NELSON. What is a cycle?

Mr. SEIBEL. A cycle is 1 quart every 2 hours.

That pavement was also subjected to 187 passages of a wheel load, a simulated wheel load, from a jet fighter.

Mr. RIVERS. Would you get the witness, Mr. Chairman, to tell us what part of the field that asphalt came from?

Mr. HESS. The core?

Mr. SEIBEL. The core came from the end of a runway.

Mr. RIVERS. Was it used or not?

Mr. SEIBEL. Yes; it was in use.

Mr. COURTNEY. You mean within the end 500 feet or a thousand feet?

Mr. SEIBEL. It is within the end of 500 feet.

Mr. RIVERS. It wasn't stuck off there by itself or hardly ever hit?

Mr. SEIBEL. No. That particular section was removed within approximately 3 months after it was put down, but it was never subjected to jet fuel.

Mr. RIVERS. I mean, was it used as much as, say, 600 feet, 700 feet, 800 feet, 900 feet of the runway, or was it out where it wasn't hit as regularly as the other portions?

Mr. SEIBEL. It was taken from a section within 200 feet of the end of the runway, toward the side, where aircraft would normally pass over the section.

What we wish to point out was what will happen when jet fuel is put on asphaltic concrete.

Mr. HESS. Very well. This is the same type of fuel that is used in a jet plane; is it?

Mr. SEIBEL. This jet fuel that we have here was obtained from a United States Air Force base from a tank containing fuel that is used to fly aircraft every day.

Mr. COURTNEY. Mr. Seibel, will you proceed now with your statement please?

Mr. SEIBEL. Thank you, Mr. Courtney.

We wish to express our appreciation of the opportunity to present our views on airfield pavements and hereby acknowledge the letters of invitation dated January 25, 1954, which Mr. John J. Courtney, special counsel for the committee, has written to us.

It is our opinion that portland cement concrete is a satisfactory pavement for all airfield areas, both critical and noncritical, based

on its many years of proven performance. The only objection to portland cement concrete pavement is its relatively high cost.

We believe that it is also a well-established fact that in noncritical areas high-grade asphaltic concrete pavement, properly designed and constructed, has proved to be an entirely satisfactory substitute for portland cement concrete. Under normal or average conditions, asphaltic concrete pavement can be constructed at materially lower costs than a portland cement concrete pavement of equal quality.

In critical areas, however, it has been demonstrated that asphaltic concrete pavements have shown a marked tendency to deteriorate when subjected to jet fuel spillage and blast from jet engine exhausts. The only inference that can be drawn is that asphaltic concrete should not be used in critical areas unless it can be positively protected from the effects of spillage and blasts.

In 1947, at the request of the United States Air Force, industry undertook the problem of finding a suitable means or method to protect asphaltic concrete pavement surfaces from the effect of jet-powered aircraft operations. For the past 7 years, industry has been experimenting with materials of many kinds and methods of great variety. Of all the developments attempted, tar-rubber surfacing has proved to be the most desirable and effective.

Test sections of tar-rubber wearing or surface course, 1½ inches in thickness, have been placed on airfields throughout the country. The first installation was made in 1948 at Baltimore's Friendship International Airport, and today, almost 6 years later, it is in excellent condition; it has required no interim maintenance. In 1952, under USAF supervision, this initial test section was subjected to jet fuel spillage and blasts from an F–80 jet-powered fighter. The tar-rubber pavement was unaffected by either the accelerated jet fuel spillage or the jet blast test. These results are a matter of record in United States Air Force files.

Subsequent installations of tar-rubber pavement have been laid under the supervision of the Corps of Engineers, United States Army, at Hunter Air Force Base, Savannah, Ga.; Presque Isle Air Force Base, Maine; Davis-Monthan Air Force Base, Tucson, Ariz., and McChord Air Force Base, Tacoma, Wash. These pavements have been in normal, routine use and have given entirely satisfactory service without any adverse effects from either jet fuel spillage or jet blasts. All of these pavements were put down with conventional asphalt hot-mix type plants and standard paving equipment; no special equipment of any kind was required.

In addition to these field installations, test sections have been put down at the Corps of Engineer's Waterways Experiment Station at Vicksburg, Miss. Mix design development, accelerated fuel spillage, blast and traffic tests have been in progress for almost 2 years. As a result of these experiments, it has been concluded that tar-rubber pavement can be designed to meet criteria established by the Air Force for heavy-duty pavement, that tar-rubber pavement is jet fuel resistant, and that tar-rubber pavement is a satisfactory substitute for portland cement concrete.

In view of these considerations, it is our opinion that the most economical, satisfactory solution to the paving problems of jet airfields will embrace (1) the use of portland cement concrete or as-

phaltic concrete in the noncritical areas on a strictly competitive basis, (2) the use of portland cement concrete or asphaltic concrete overlayed with tar-rubber in the critical area; again, on a strictly competitive basis.

We would like to point out that if the combination of asphaltic concrete in the noncritical areas in combination with asphaltic concrete and tar-rubber in the critical areas is adopted, the same standard equipment can be employed for the entire project. This will eliminate the complications which could arise through awards to two contractors or the employment of a subcontractor with specialized equipment.

It is our conclusion that the cost of the combined asphalt tar-rubber pavement is slightly higher than that of standard asphaltic concrete pavement and materially lower than equivalent portland cement concrete pavement.

Mr. COURTNEY. Mr. Seibel, may I ask you this question: Do you have specific instances of bids on a comparative yardage cost of the type of combination you are speaking about as against concrete?

Mr. SEIBEL. There are figures covering the projects which we mentioned here in our paper but we would like to point out that while we certainly know what we can expect when volume is developed, the contractors who bid on these projects were unaware at the time they submitted their bids just what problems they would have in laying tar-rubber pavements. It being new to them, they certainly wanted to make sure that their bids contained sufficient room to prevent any possible loss of profit to them.

Mr. COURTNEY. What you are saying is that because this is a new art, or a new development, the figures would be rather higher than they would normally be expected to be?

Mr. SEIBEL. That is what I mean to point out, Mr. Courtney.

There is one project mentioned in the Asphalt Institute's paper, which you mentioned this morning, the McChord Air Force Base, where there was a differential of approximately $2 a square yard between the tar-rubber overlayed on an asphaltic and portland cement concrete.

Mr. HESS. Tar-rubber is overlayed on the asphaltic concrete?

Mr. SEIBEL. Yes, sir.

Mr. HESS. You put a covering over of tar-rubber?

Mr. SEIBEL. Yes, but it is not a cover in addition to the normal concrete. It is a substitute for the top 1½ inches of asphaltic concrete pavement.

Mr. RIVERS. What you do is, in building an airport, you substitute for that last 1½ inches, which includes the bonding, you put this tar-rubber mixture down?

Mr. SEIBEL. Yes, sir. Flintkote and United States Rubber——

Mr. RIVERS. You put that in the areas where they now specify critical or concrete?

Mr. SEIBEL. Yes. That is what we recommend; yes, sir.

Mr. RIVERS. Do you say for that yardage, say it is 10,000 square yards, for that yardage you can compete with that number of yardage of concrete?

Mr. SEIBEL. Yes, sir.

Mr. RIVERS. Or is your testimony to the effect that coupled with the remaining yardage of asphalt, it would be cheaper than that coupled with the remaining yardage of asphalt and concrete?

Mr. SEIBEL. We have not gotten involved in being coupled with any other section; no, sir.

Mr. RIVERS. You mean yard for yard?

Mr. SEIBEL. Yes.

Mr. RIVERS. And that durability is there, the longevity is there, you can compete with them?

Mr. SEIBEL. Yes, and we have sections down which show that.

Mr. RIVERS. And you can do it cheaper?

Mr. SEIBEL. Yes.

Mr. RIVERS. Is your rubber synthetic rubber?

Mr. SEIBEL. It is synthetic rubber. Or I should say, a mixture of synthetic rubber and coal tar.

Mr. HESS. Is it used on any Air Force base where jets are operated at the present time?

Mr. SEIBEL. Yes, Mr. Hess. Jets are operating at Davis-Manthan and at McChord Air Force Base and at Presque Isle Air Force Base. I am not sure about Hunter but I think they are there.

Mr. HESS. How long has the tar been on those bases?

Mr. SEIBEL. The project at Hunter, it was put down in May 1952.

Mr. RIVERS. Do the contractors require any specialized training to utilize these tools?

Mr. SEIBEL. No, sir.

Mr. RIVERS. Just specialized thinking?

Mr. SEIBEL. Yes, sir.

Mr. RIVERS. They were reluctant to do it because of it being a new thing?

Mr. SEIBEL. Well, most people are fearful——

Mr. RIVERS. I understand, all contractors are, even in building a house, and I know something about that.

Mr. SEIBEL. It is interesting to note that several of the contractors who put down the tar-rubber pavement, after the jobs were over expressed their complete surprise at the ease with which the material went down. And some of them even expressed that they thought it laid a little better than asphalt concrete.

Mr. RIVERS. Has this material been subjected to B–46, or B–47 plus the blast of each of them?

Mr. SEIBEL. The material as designed is designed to take care of and withstand 100,000 pound wheel loads, on 200 p. s. i. tire pressure, which is the criteria established for heavy bombers, that is; the existing criteria.

Mr. COURTNEY. You mean that is the Air Force criteria?

Mr. SEIBEL. Yes, sir.

Mr. COURTNEY. Or whoever may use the field.

Mr. SEIBEL. Yes, sir.

Mr. COURTNEY. Presumably that encompasses the developments still on the drawing boards.

Mr. SEIBEL. Let me put it this way, the tar-rubber pavement will stand any load that the Air Force thinks it must.

Mr. FISHER. Mr. Chairman——

Mr. HESS. Mr. Fisher.

Mr. FISHER. Mr. Ferry, the assistant Secretary of the Air Force in charge of construction, in his testimony referred to this special work, as he called it in his testimony on yesterday, and he states experimental work has also been initiated in the interest of reducing the cost of concrete pavement, we are at present collaborating with industry in the development of a tar-rubber paving mixture that shows considerable promise. He refers to this experimental work.

Do you regard it as still being in the experimental stage, the successful proven usability of it?

Mr. SEIBEL. We do not consider it experimentation any more: no, sir. We do not consider it experimental any more.

Mr. FISHER. Do you think its usefulness has passed the experimental stage and is now well established by actual experience in the field?

Mr. SEIBEL. Yes, sir; we do.

Mr. RIVERS. Don't you have to put a sign at the end of that runway "Slippery When Wet"?

[Laughter.]

Mr. SEIBEL. No, sir.

Mr. CUNNINGHAM. Mr. Chairman——

Mr. HESS. Mr. Cunningham.

Mr. CUNNINGHAM. Mr. Seibel, at what places on a runway and under what conditions is asphaltic concrete inferior to portland cement?

Mr. SEIBEL. Referring to the statement made here, we feel that asphaltic concrete is inferior to portland cement concrete in critical areas.

Mr. CUNNINGHAM. By critical areas you mean certain portions or parts of a runway or airfield?

Mr. SEIBEL. By critical areas I mean those areas designated by the Air Force and the Navy as being critical.

Mr. CUNNINGHAM. If they would just designate them all critical you would be out of the running, wouldn't you?

Mr. SEIBEL. No, if they were all critical, we would recommend tar-rubber pavement for the entire airfield.

Mr. CUNNINGHAM. But you wouldn't come into it if it was only partially critical?

Mr. SEIBEL. We don't think there is a need for putting tar-rubber paving in areas other than where it is critical because it costs more than asphaltic concrete, but less than concrete.

Mr. FISHER. You referred to the Vicksburg experiment plant of the Army engineers in your statement. Have they experimented down there with this tar-rubber treatment?

Mr. SEIBEL. Yes, sir. They have been working on a project for almost 2 years.

Mr. FISHER. They have undoubtedly accumulated some data and information based upon inspections and experience that they have had in these tests?

Mr. SEIBEL. There have been several reports written; yes, sir.

Mr. FISHER. They have made reports on it?

Mr. SEIBEL. Yes, sir; they have.

Mr. HESS. Mr. Nelson.

Mr. NELSON. What is the Flintkote Co.?

Mr. SEIBEL. The Flintkote Co.—I will make it as brief as I can—is primarily comprised of two divisions, the building materials division, for which it is best known, and an industrial products division, of which the paving products sections is a part.

We are engaged primarily in the sale of building materials and specialties for the industry.

Mr. NELSON. Are you the sole agent for the distribution of it?

Mr. SEIBEL. I am not an agent. I am an employee of the Flintkote Co.

Mr. NELSON. I mean; is the Flintkote Co. sole agent for the distribution of its product?

Mr. SEIBEL. I head up the paving products section, under which tar-rubber is a product.

Mr. NELSON. Are they the sole agents for this particular product you are talking about?

Mr. SEIBEL. We manufacture tar-rubber pavement, which is known as Flint binder C–2.

Mr. NELSON. Does anyone else manufacture it?

Mr. SEIBEL. There is another tar-rubber pavement, which Mr. Tauber can explain better than I.

Mr. NELSON. Is it comparable to this one?

Mr. TAUBER. We think so. Perhaps better than theirs.

Mr. NELSON. Is that the one that United States Rubber makes?

Mr. TAUBER. Yes.

Mr. SEIBEL. I regret having yielded to Mr. Tauber.

(Laughter.)

Mr. NELSON. Tell me, have you made any tests which might indicate the longevity of this particular substance as compared with concrete?

Mr. SIEBEL. The initial installation was put down in 1948. It is still in excellent condition. There are all indications that there is no difference between its longevity and that of other types of pavement.

Mr. RIVERS. Mr. Chairman——

Mr. HESS. Mr. Rivers.

Mr. RIVERS. Mr. Chairman, for the record: I know that the witness is not fortunate enough to have attended school in South Carolina, but he indicates quite a bit of education, and for the record will you give us your background, Mr. Seibel?

Mr. SEIBEL. I am a graduate engineer of the Carnegie Institute of Technology.

Mr. RIVERS. There are are other good schools. I say that he knew what he was talking about, Mr. Chairman, and I wanted it for the record.

Mr. SEIBEL. Thank you, sir.

Mr. HESS. Mr. Tauber, do you have any statement to present?

Mr. TAUBER. No, sir. We cooperated on that one, to make it brief and to the point.

Mr. HARDY. Mr. Chairman, I would like to observe that I think Mr. Nelson put his finger on the key point, if the Flintkote Co. had a monopoly on this business it wouldn't be long before the price would be higher than that of portland cement.

Mr. SEIBEL. On the contrary, Mr. Hardy, in every instance where tar-rubber pavement has been put down, the product of the United

States Rubber Co. as well as that of the Flintkote Co. products have been put down; on the contrary to the price going up, it will go down, based on experience that I, as representative of Flintkote Co. have had, doing business against the United States Rubber Co.

Mr. HESS. Are any other rubber companies experimenting with a similar product?

Mr. SEIBEL. Yes, sir.

Mr. RIVERS. May I inquire for the record: Who owns the basic patents?

Do you cross-license each other?

Mr. TAUBER. No, we play our own little game. Synthetic rubber is not an unknown quantity now. All of the rubber companies have plants or will have plants. So it will be a very free competitive material.

Mr. RIVERS. At this time who owns the patents?

Mr. TAUBER. I don't believe there are any patents.

Mr. SEIBEL. There are no patents.

Mr. FISHER. Let me ask you this question now: You say there are or will be. At this time is there very much production, or productive capacity of this tar-rubber? Do you have that problem in bids, that contractors make, as to the capacity of the rubber companies to supply this tar-rubber?

Mr. SEIBEL. No, sir. We anticipate no difficulty in that regard whatsoever.

Mr. FISHER. You are prepared to supply the demand?

Mr. SEIBEL. Yes, sir.

Mr. HESS. Let's go down here now and take a look at this demonstration.

Mr. HESS. Mr. Courtney.

Mr. COURTNEY. The cores that you have shown containing the mixture of tar-rubber were taken from the experimental laboratory at Vicksburg, Miss.?

Mr. SEIBEL. Yes, from the waterways experiment station but not from the laboratory, from a section in the field at that station.

Mr. COURTNEY. In other words, those are the cores that were being used in the tests which Vicksburg has talked about?

Mr. SEIBEL. Yes.

Mr. COURTNEY. Now what tests have been made of the effects of blasts, heat on pavement of that kind?

Mr. SEIBEL. As we mentioned in our statement here, the pavement put down in 1949, at Baltimore, Md., Friendship International Airport, was subjected to, I believe it was 5 minutes—Mr. Tauber, you were there——

Mr. TAUBER. It was 5 minutes at a half hour, and 5 minutes at a full hour, with the wheels in a fixed position, so that the pattern of blast or the impingment areas were fixed. That is a jet aircraft, F–80.

Mr. SEIBEL. The one that is supposedly the most damaging to pavement with respect to blast.

Mr. COURTNEY. You don't know of any other experiment on pavement with respect to blast?

Mr. SEIBEL. There were blast tests run at Presque Isle airfield in the section put down there.

Mr. COURTNEY. And at the other Air Force bases?

Mr. SEIBEL. At Hunter Air Force Base too, yes, sir.
Mr. COURTNEY. I think that is all.
Mr. HESS. Are there any other questions?
We will recess at this time.
Thank you, gentlemen, for coming here.
We will recess at this time until 2 o'clock, at which time, I believe, we will hear from the portland cement people.
(Whereupon, at 12 noon the committee adjourned until 2 p. m. of the same day.)

AFTERNOON SESSION

The subcommittee reconvened at 2 p. m., the Honorable William E. Hess, chairman of the subcommittee, presiding.
Mr. HESS. The committee will come to order, please.
Mr. Courtney.
Mr. COURTNEY. Mr. Chairman, the record was not clear at the close, one question of Mr. Seibel and Mr. Tauber.
Is your product a patented product, a proprietary product, or not?
Mr. SEIBEL. Flintkote Co. product is not patented, sir.
Mr. COURTNEY. It is not a proprietary product?
Mr. TAUBER. United States——
Mr. COURTNEY. It is proprietary in the sense that you make it, but it is not a patented product; is that right?
Mr. SEIBEL. That is right.
Mr. TAUBER. The United States Rubber Co. product is not patented.
Mr. COURTNEY. Anyone can make it?
Mr. TAUBER. That is right, any rubber company can produce it, anywhere.
Mr. COURTNEY. I just wanted the record to be clear on that, before your testimony closes.
Mr. Chairman, the Portland Cement Association has been invited to present what information is available from their industry on the subject of our inquiry. And we have Mr. G. Donald Kennedy, its executive vice president, who sits there directly in front of me in the brown suit, and at his left and your right as you face him is Mr. A. Anderson, their chief highway consultant.
On the left as you face the witnesses, Mr. H. A. Humphrey, a paving engineer, and on his opposite side is Mr. Gordon K. Ray, paving engineer, both with the same institute.
Mr. HESS. All right.
Mr. COURTNEY. Mr. Kennedy, Mr. Chairman, has a prepared statement.
Mr. HESS. You may proceed, Mr. Kennedy. Have a chair, unless you prefer to stand.
Mr. KENNEDY. It is quite all right, sir.

TESTIMONY OF G. DONALD KENNEDY, EXECUTIVE VICE PRESIDENT, PORTLAND CEMENT ASSOCIATION OF CHICAGO

Mr. KENNEDY. Members of the Subcommittee on Defense Activity of the Committee on Armed Services, and counsel.
My name is G. Donald Kennedy and I am executive vice president of the Portland Cement Association of Chicago, Ill. I am a registered

engineer, certificate No. 234 in the District of Columbia, as required by Public Law 789 of the 81st Congress.

Thank you for the invitation to present to the subcommittee our convictions that portland cement concrete is the paving material best suited for airfield construction.

It is a great privilege and honor to be here.

Associated with me, as the counsel has pointed out, is Mr. Anderson who has had wide experience in concrete pavement construction for many years throughout the United States. Mr. Humphrey who has recently completed extensive inspections of many airfields throughout the country, and Mr. Ray, who is a specialist in the design of concrete pavement.

The Portland Cement Association is a national nonprofit organization voluntarily supported by 68 member companies engaged in the manufacture of portland cement in the United States and Canada. Its headquarters are in Chicago.

The association's work consists of such activities as scientific research, development of new products, promotion, educational work and technical engineering service to improve and extend the uses of concrete.

To carry out this work the association maintains a headquarters staff of more than 180 scientists, professional engineers and other specialists and a field organization of more than 300 engineers, architects and others working out of 27 district offices.

These men are in daily touch with design and construction problems throughout the country.

The association is in no way engaged in the manufacture, pricing or sale of cement.

CONCRETE PAVEMENT IS BEST FOR MILITARY AIRFIELDS

With the rapid development in the number, speed, weight and performance of jet airplanes, with accompanying increases in heat, thrust and blast, there has been a growing recognition of the need for military airport pavement adequate to provide safe, efficient and durable facilities for jet operations. This is indicated by frequent changes in directives relating to the construction of airport pavement for jet operations.

The first concrete airport pavement in this country was constructed more than 25 years ago. Today there are over 240 million square yards of concrete airport pavements in use at some 820 airfields in this country. The service rendered by concrete pavement has established it as the best type for airport use.

Many of the first concrete airfield pavements built in 1928–30 are still serving despite the tremendous increases in aircraft wheel loads since that time. With the improvement of engineering design and construction practices, it is safe to predict that the service life of concrete airfield pavements will be much greater than that of the older pavements.

Concrete pavement has the properties needed for airports, both civil and military. Some of these properties are:

1. A concrete pavement is an enginering structure. The rigid slab has inherent beam strength designed to carry the load. This beam strength distributes the pressure from extremely heavy wheel loads

over such a large area that unit pressures at any point on the supporting soil are relatively low. Flexible pavement types do not have rigid structural strength. On these pavement types the pressures applied by the load are concentrated on the subgrade directly underneath the load.

The relative distribution of the load is clearly shown on the chart taken from the work of Hogentogler and Tersaghi, two of the Nation's foremost soils specialists.

Mr. COURTNEY. May I interrupt. Is that Mr. Hogentogler who lived in Washington?

Mr. KENNEDY. Yes, sir.

Mr. COURTNEY. Who is recently deceased?

Mr. KENNEDY. Yes, sir, the same. This shows the load distribution on flexible pavement and on concrete pavement and you will note beneath the flexible pavement the distribution of load occurs in large magnitude directly beneath the wheel load. You will notice on the concrete pavement that the distribution of the load occurs over a large area and in lesser magnitude.

2. Concrete pavement is designed in accordance with established engineering principles. Exhaustive and severe loading tests and inspections of pavement in service in all parts of the country have been used to check and confirm the engineering methods of pavement analysis. The engineer can design the pavement with the assurance that it will carry any required loads on the existing soil, yet will not be wastefully overdesigned.

On chart No. 2, a picture released by the Consolidated Vultee Co.: the YB–60 is shown at Carswell Air Base, Tex., on concrete pavement. That particular plane is 400,000 pounds in load, 50,000 pounds as a matter of wheel load and carries 200 pounds per square inch tire pressure.

3. There are hundreds of experienced contractors with the most modern construction equipment and skilled personnel fully competent to build modern airport pavement to the highest engineering standards.

4. Concrete pavement is designed and constructed to drain rapidly without excessive crown. The low crown reduces the tendency of airplanes moving on it at high speeds to swerve toward the edge of the runway. This is a major factor in safe operation. The method of shaping concrete does not lead to the formation of water pockets. It is, therefore, free from depressions which retain water and corrugations that create hazards.

5. Concrete pavement's rigid surface is ideal for airplanes. Its tractive resistance is low as it does not deform under the wheel loads. Thus there is a minimum of rolling friction, allowing planes to attain flying speed rapidly even with maximum load of fuel, ammunition or other cargo. What this means to military operations is readily apparent.

Concrete does not develop ruts or depressions under standing aircraft. There is no need for constant shifting of aircraft locations on aprons. On concrete, excess power and fuel are never needed to move aircraft from standing positions since depressions do not form under the wheels.

6. Concrete's true, even, gritty surface texture insures adequate skid resistance and braking ability, further adding to safety and con-

serving valuable equipment. With the high speed landings of today's jets, the ability to make safe stops is a vital factor to all military pilots.

7. Concrete's high visibility, day and night, is an added safety factor, either for experienced pilots or for those in training. No one needs to emphasize the importance of visibility to the flyer. Concrete has maximum visibility as an integral part of the pavement because of its natural light reflecting color.

Even the joints on a concrete pavement add to flyer's ease of operation. The "grid effect" of the joints gives the flyer a depth perception and enables him more accurately to judge his elevation—thus making for safer landings.

8. Concrete is free from loose chips or other particles. Always dangerous to equipment and personnel, these loose particles become even more objectionable with jet engines which are particularly susceptible to destruction from foreign material being blown or sucked into the intake. Any loose material on a pavement is easily kicked up by the nose wheel or blown into the air by the blast from another plane. The loss of only one jet engine could offset any possible difference in first cost of an entire concrete runway as compared with a runway using a "low first cost" type of pavement. This danger of loss will become more serious as the number of jets using the runways increases.

And in chart No. 3, a picture is taken from Consolidated Aircraft Corp., the B–36D, and from the Boeing Airplane Co., News Bureau, the B–47. You are shown that concrete has high visibility, better skid resistance, even uniform surface, and freedom from loose particles.

On your right is the B–36D, and on your left is the B–47.

9. Snow removal is easy on concrete. The surface of a concrete pavement is not damaged by snowplow blades or by flame-type ice-melting machines.

10. Concrete pavement is comparatively free from periodic repairs, treatments or resurfacings which interrupt the continuity of service. No special seal coats are necessary to protect from fuel spillage, increase skid resistance or to correct for other deficiencies in the pavements.

11. Concrete pavement surfaces do not become tacky or sticky but retain their original rigid, durable surface when subjected to heat or jet fuel spillage. There is no possibility of sticky excess material, picked up by wheel or foot traffic, interfering with jet operation. No extra cleaning of landing gears is necessary to protect against malfunctions due to sticky pavement surfaces.

12. High pressure tires which are used with jet planes involve no special problem when concrete is used. Experience with tires having pressures up to 240 pounds per square inch has shown that they do not affect concrete. In fact, the nature of the concrete surface is such that these high pressure tires, or even those with much higher pressures, cannot damage it. Locked wheel turns or sudden stops cannot mar or scuff the surface.

The steel-wheeled dollies and maintenance equipment frequently operating on aprons require concrete pavement.

13. Concrete is not damaged by softening or other deterioration due to spilled fuel. Blasts from jet exhausts do not erode concrete, nor do they affect the stability of the surface. Concrete pavements will stand up under jet operations.

Special tests to determine the effects of jets on pavement by the Air Force at Eglin Field and the Navy at Port Hueneme show concrete to be the most highly resistant of all pavement to the effect of heat and fuel spillage. In protracted tests jet exhaust blasts which caused surface temperatures up to 800° F. had negligible effect on the concrete.

And in chart No. 4 we show in this picture taken from the Boeing Airplane Co. the YB–52. Jet aircraft needs concrete pavement, in our experience, to withstand jet blasts, high surface temperature and fuel spillage.

Concrete pavements have proved their ability to take even higher temperatures in guided missile launching pads at both Patrick Air Force Base and Point Mugu Naval Air Station. At the Ohio River Division Laboratories, special tests by the Corps of Engineers studying the heat resistance of concrete and the effects of rocket-assist-take-off RATO indicate that concrete pavements can be built to stand up under temperatures of 2,200° F.

In chart No. 5 we show some of these tests. These pictures of the slabs are taken from the Ohio River Division Laboratories. This is a resolving teststand, where rockets were pointed directly at the concrete and revolved in a series of tests and show no appreciable damage to the concrete at the completion of the test. The F–84 is taken from an official Air Force photograph from Edwards Air Force base. The F–84 makes rocket-assist-take-off from concrete as shown in that picture.

Since experience has shown concrete is the only satisfactory pavement for today's jets, it will be even more necessary in the future. Aircraft manufacturers and military materiel officers all agree that heat and blast problems will be even more serious on future aircraft. We must be sure that we are not building a type of pavement now which will be inadequate tomorrow. Taxpayers' dollars are protected by building concrete airfield pavement.

In Chart No. 6 we take a look at the future. This picture appeared in the Chicago Daily Tribune on January 29, 1954, and shows a series of experimental planes under test at Edwards Air Force Base in California. In the center is the Douglas X–3, and clockwise from the lower left is the Bell X–1A, the Douglas D–558 jet of the Navy, the Convair XS–92, the Bell X–5, the Douglas D–558, a rocket Navy plane, and the Northrop X4.

If these are present-day experimental aircraft that can be published in the daily newspapers of the newspapers of the United States, we may well ask what are the aircraft in the planning and design stage that are not exposed to public view.

No. 14. A survey of flying personnel and engineering officers directly charged with pavement upkeep will show that concrete pavements are preferred.

Pilots, operations officers and maintenance officers at the bases or in the various commands where they come in direct contact with problems of flying maintenance of pavement are most emphatic in their preference for concrete. In fact, many of these men, speaking from experience, insist that only concrete will serve satisfactorily where jet operations are involved.

Military men are not alone in their preference for concrete. Aircraft manufacturers and commercial airlines are almost unanimous in their choice of concrete for their own pavement installations.

This was true before the development of jet propulsion—it is even more true today. The properties of high visibility, low rolling friction, excellent skid resistance, good braking surface, low crown, freedom from loose particles, were always important and are still more important in the jet age. Today, concrete's ability to stand up under jet operations makes it even more the choice of the men who use it and take care of it. With the older propeller-type planes, loose particles on runways caused only propeller damage. Today the same particles can destroy jet engines or the entire plane and crew.

15. Concrete is a long life, economical pavement designed for future jet plane requirements. Sometimes the first cost is more than other types of payment, but its longer life and low maintenance charges make it cost less per year of service. Its better performance through the years actually saves money and protects taxpayers' dollars. Experience shows there is ever justification for the use of concrete pavement. The only excuse for the use of another type is the possible saving in first cost. To use this excuse is to ignore the lower annual cost of concrete and the lower cost of operating aircraft from its surface. It also ignores the many other plus factors of concrete that have been enumerated herein.

Concrete airfield pavement technology has kept pace with the jet age. Research in the field and in the laboratory, new materials, new techniques and new equipment have all resulted in stronger, safer, more durable concrete pavements. These improvements will insure an even longer service life.

The adoption of air-entrained concrete has been one of the biggest advances. The purposeful entrainment of minute, widely dispersed air bubbles in the concrete has resulted in pavements which do not scale, even though de-icing salts or abrasives containing de-icing salts are used to remove ice and snow. Air entrainment has also improved the workability of concrete which has resulted in a high degree of surface uniformity.

Concrete pavements are composed of materials which are widely available throughout the United States. All of the ingredients are in abundant supply. Concrete roads, streets, and airfield pavements have been built in every 1 of the 48 States.

The construction price of any pavement will vary depending on size of project and locality. Local prices for material, equipment, transportation facilities and labor all influence the price of the finished pavement.

The possible difference in price between concrete and low-first-cost pavement types is a small percentage of the total pavement cost, and when years of service, maintenance costs, safety of planes and personnel are taken into account, modern concrete airport pavement is the lowest of any comparable type and represents the wisest expenditure of taxpayers' money.

In chart No. 7 we show a comparison. The best planes deserve the best pavement. Concrete cost is only one-third of the cost of one jet bomber.

While the figure of the cost of a modern bomber is an approximate figure at $5 million, the cost of one heavy duty runway is $1,440,000. Protect your investment with concrete.

Mr. NELSON. That is only one runway. How many runways do you have in that picture?

Mr. KENNEDY. There are three runways in that picture.

Mr. NELSON. Three?

Mr. KENNEDY. Yes.

Mr. HUMPHREY. Here, here, and here. This is the taxiway setup.

Mr. HARDY. You have got to pave your taxiways, too, don't you, or are you going to put them down in asphalt?

Mr. KENNEDY. Your question, sir.

Mr. HARDY. You have to have taxiways and so forth, unless you are going to let them go down in bituminous.

Mr. KENNEDY. No, indeed.

Mr. HARDY. I just thought you would have included the entire cost, so we would have a comparative proposition. You can't operate an airfield like that without taxiways.

Mr. KENNEDY. The bombers use one runway at a time and of course we have a large number of bombers. We are building airbases and bombers to cover the United States. We could make a total-cost comparison, I suppose, of all of the airport runways and make a total cost of all of our bombers.

Mr. HARDY. Well, I don't think that is necessary.

But I just was thinking here: You talk about the cost of one runway. I do think—of course you have some fields that have only one runway I think now.

Mr. KENNEDY. That is correct.

Mr. HARDY. But even so, I think that you would have to include—if you are going to make a comparison, you are going to have to include the cost of your accessory paving as well as the runway itself.

Mr. KENNEDY. I agree with you, sir. If you are making a total economic comparison, I agree. This example is related to the safety and operational problems of a given bomber under a given set of circumstances.

America is developing the best Air Force in the world. You are buying the best planes, the best armament, and the best electronic equipment money can buy. These planes must have adequate pavements from which to operate. To provide any paving material that has not been proved durable under all conditions of exposure is jeopardizing the national-defense effort.

Following this statement in the folder that you have, gentlemen, is a series of quotations taken from a number of individuals, officials and publications relating to individual opinion with respect to concrete pavement.

WHAT OTHERS SAY ABOUT THE ADVANTAGES OF CONCRETE PAVEMENT

As further proof of the advantages to be gained from using concrete for airfield pavements, I would like to present the following statements, together with references:

Director of Installations, United States Air Force (1):[1]

[1] Numbers refer to references listed on last page.

Although the Air Force builds two types of pavement—concrete and asphalt—it does not consider them equal. The senior commanders of the Air Force strongly indicate at every opportunity their preference for concrete pavement without exception. * * * When separate schedules of concrete or asphalt are closely bid, the Air Force is usually willing to pay a small premium for the concrete in expectation of getting a more suitable pavement for long-term use.

Chief, Bureau of Yards and Docks, United States Navy (2):

For instance, as the text points out, no bituminous surfacing yet known can withstand the heat of jet exhausts. This makes it imperative that runway ends for jet plane traffic be surfaced with concrete.

Another factor of change is the increased use of high-pressure tires, which require tougher pavement and more rigid specifications than low-pressure tires.

Douglas Aircraft Co. (3):

Existing nonafterburning operational aircraft produce only negligible damage to concrete pavement, and even this damage should be relieved by current paving procedures. Airport pavements should be concrete at all locations where jet aircraft are expected to be stationary with engines operating.

Charles R. Foster, Corps of Engineers, Flexible Pavement Laboratory, Vicksburg, Miss. (4):

Describing results of joint Air Force-Corps of Engineers tests on effects of jet blasts at Eglin Field, Fla. Tests by 8 different Air Force jet planes for periods up to 21 minutes showed—

The maximum temperature was recorded during a maintenance runup with a bomber on asphaltic concrete which produced a temperature of 385° F. This produced serious erosion. * * *

Minor erosion of the asphaltic concrete occurred from the jet blast when the pavement temperature reached about 300° F. * * *

Temperatures in the portland cement concrete were generally 30° to 70° less than in the asphaltic concrete.

Portland cement concrete pavements were not affected by the blasts. * * *

Fred R. Payne, Jr., North American Aviation, Inc. (5):

On future trends in aircraft—

As a quantitative estimate present jet velocities and temperatures are in the region of 1,500 feet per second and 1,300° F. Future velocities and temperatures of afterburning turbojets and rockets will be in the order of 2,000 to 8,000 feet per second and 3,500 to 5,000° F.

E. A. Rock, Boeing Airplane Co. (6):

Research should be conducted with the view in mind of supplying to the aircraft designer pavements to withstand stoichiometric temperatures, with exhaust velocities consistent with jet-engine development, angles of inclination of 0° to 20° and tailpipe elevations of 1 foot and up.

S. A. Wallace, USAF installations representative, South Pacific Division, San Francisco, Calif. (7):

Therefore, modernizing the pavements should include selection of a type of pavement which is durable and has an economical maintenance factor. Certain areas, such as all parking aprons, runway ends, and taxiway turns, should be portland cement concrete.

Aviation Week magazine (8):

In a truce report from Korea states:

In some ways Fifth Air Force is in better shape than ever. Its fighter-interceptor force was doubled by reequipping two fighter-bomber wings with the F–86F.

The airfield situation is much better. Most runways are in the 9,000-foot class and of concrete.

Contractors and Engineers magazine (9):

Describing surface maintenance at the Elmendorf Air Force Base, Anchorage, Alaska, where jets are operating under severe weather conditions—

Joint pouring is about the only routine maintenance on concrete.

Aviation Week magazine (10):

From a Korean war dispatch:

The result is that F–80's can take off with only two 5-inch rockets, except during the first hours of the morning when it is cool. Then they get off with four. Normally, the F–80 should carry eight rockets. With a good concrete strip there would be no difficulty.

REFERENCES

(1) The Effect of Jet Conversion Program on Air Installations, Maj. Gen. Lee B. Washbourne, the Military Engineer, volume XLV, No. 306, July–August 1953.

(2) United States Navy technical publication Airfield Pavement, Navy Docks TP PW 4, foreword by Rear Adm. J. F. Jelley, January 1, 1953.

(3) Effect of Aircraft Jet Engine Exhaust Impinging on Airfield Surfaces, by N. L. Fox and S. V. Harvey, Santa Monica division, Douglas Aircraft Co., Report No. SM 14735, December 1953.

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That, sir, completes the reading of our direct testimony.

Mr. HESS. Thank you, Mr. Kennedy, very much.

Mr. Hébert, have you any questions?

Mr. HÉBERT. I think the statement is a very fine statement in favor of concrete, but it is not a statement that is in dispute. What I am interested in is about the all-concrete airport as compared to the feasibility and economic value of placing the critical areas of concrete and the noncritical areas with asphalt. I think the asphalt presentation itself quite readily admitted that the concrete, the cement, was preferable to the asphalt. Their objection, as I understand it, is the all-out concrete airport, where it is not absolutely necessary.

Mr. KENNEDY. You refer to the airport as now covered in the current directives of the Air Force, the naming of certain critical areas which are either concrete or compared——

Mr. HÉBERT. That is correct, and the asphalt representatives addressed themselves to that phase.

Mr. KENNEDY. We believe that the Air Force has justified to this committee and proven the necessity of the use of concrete in all critical areas.

Mr. HÉBERT. That is not in dispute. That is the point I am making. We admit that. Everybody admits that. There is no discussion there. But our interest is, as I understand, the use of asphalt com-

pared to concrete in noncritical areas. Now, you haven't addressed yourself to that at all.

Mr. KENNEDY. Well, we believe, sir, that the Air Force has given you its present thinking with respect to airports and the development of construction which will meet the problems of the future.

It is our opinion that concrete is the best paving material and that it should be used on all airport areas where jet operations are contemplated.

Mr. HÉBERT. Well, both critical and noncritical areas.

Mr. KENNEDY. Both critical and noncritical areas.

Mr. HÉBERT. Well, the Air Force doesn't subscribe to that.

Mr. KENNEDY. The Air Force does not subscribe to that. We believe that the Air Force has good and valid reasons for adopting the policy that it has at the present time.

We do believe, however, that this matter is so critical and affects the future to such a great extent and with the increasing weight, place and temperatures involved, that it would be prudent to use concrete over the entire airport area.

Mr. HÉBERT. Well, that is the statement. In other words, you are advocating the use of concrete everywhere?

Mr. KENNEDY. Yes, sir.

Mr. HESS. Mr. Kennedy, you don't figure it might be possible that at some future time the heat or the blast might be eliminated to a certain extent and spillage might be eliminated, so that those preblems wouldn't face us any more?

Mr. KENNEDY. Within our experience, Mr. Chairman, there doesn't seem to be evidence that the problem is moving in that direction. The tendency in the design of aircraft seems to be for heavier and hotter and greater blast and having greater impingement on the pavement.

Mr. HÉBERT. Now, in your statement, you indicate that the maintenance of concrete is far less in the long run than asphalt. I think I asked that question also of the asphalt people, which, of course, is a very proper argument to make in your favor. Now they, as I recall their testimony, made the statement that it was equally economic to maintain asphalt with concrete over a long period of time. Now, you make another statement, but don't—you just make the statement, that is all. Now what facts do you have to back that up, that yours is cheaper?

Mr. KENNEDY. We have here, which I would like to submit for the record, a series of road surface maintenance costs taken from the records of 28 State highway departments, indicating the relative maintenance cost. And this booklet will show that the maintenance costs are less for concrete than for bituminous pavements.

I think that that has been the historical experience for many, many years in activities relating to pavements. And here is evidence of that fact.

Mr. HÉBERT. Do you have any figures related to airport maintenance?

Mr. KENNEDY. We have some figures related to airport maintenance. They are perhaps not valid because of the present situation.

But I have here some figures from the Strategic Air Command in 1951, showing that the cost of maintenance of concrete pavement was three-tenths of a cent per square yard per year and that the cost of

maintenance of a high-type bituminous pavement was six-tenths of 1 cent per square yard per year. That is double.

Mr. NELSON. What are those figures from?

Mr. KENNEDY. The Strategic Air Command costs for 1951.

We have some Air Defense Command figures for 1952, which show a much closer relationship.

Mr. NELSON. Mr. Kennedy, to pursue your point, General Washbourne testified this morning, made a general statement, that there were 150 asphalt fields to about 50 of concrete. Isn't that true?

Mr. KENNEDY. We seem to agree that that was the statement, sir.

Mr. NELSON. And most of the concrete fields have been recently constructed; have they not?

Mr. KENNEDY. No.

Mr. NELSON. What is your oldest field?

Mr. KENNEDY. The oldest concrete airport dates back to about 1928.

Mr. NELSON. Is that still in operation?

Mr. KENNEDY. That is still in operation.

Mr. NELSON. Where is it located?

Mr. KENNEDY. Glendale, Calif.

Mr. NELSON. It is the original airstrip?

Mr. KENNEDY. Yes, sir.

Mr. NELSON. Nothing has been done to the concrete?

Mr. KENNEDY. You are correct, sir. Nothing has been done to it.

Mr. NELSON. It hasn't been resurfaced?

Mr. KENNEDY. No.

Mr. NELSON. Well, how long have the airports using jets been built, that are built with concrete?

Mr. KENNEDY. World War II airports were, of course, preceding the jet age, and as the jet-type aircraft have come in they have been using many of the airports that were built of concrete during World War II.

Mr. NELSON. How many of those are there?

Mr. KENNEDY. Mr. Nelson, there were 200 million square yards of pavement, laid during World War II.

Mr. NELSON. That is in military airports?

Mr. KENNEDY. Concrete military airports. Approximately 400 bases.

And those have all been available to the use of the jet age since that time.

Mr. NELSON. I understand that, Mr. Kennedy. But I call your attention to General Washbourne's testimony this morning where he said 50 were concrete and 150 asphalt, of the operational bases.

Now, let's restrict the evidence to that. How many of those 50—how old are those 50 operational bases that are built with concrete?

Mr. KENNEDY. Well, we wouldn't have those figures available. I think you would have to get those from the Air Force.

Mr. NELSON. Well, if you take the operational maintenance cost that you have just quoted, you would have to consider how long the field had been in operation in order to consider how much weight should be laid on it.

Mr. KENNEDY. That is right.

Mr. NELSON. We don't have the evidence, but if the concrete fields are new fields naturally the cost of maintenance would be less than an asphalt field that was an old one, wouldn't it?

Mr. KENNEDY. If those facts were the fact, sir, that would probably then be true.

Mr. NELSON. So that in order to make your figures valid, you will have to show us whether the concrete fields were new or old and the asphalt fields were new or old. To get a valid comparison, we have to have a comparison between a field built of asphalt and a field built of concrete and built at the same time.

Mr. KENNEDY. That would be correct.

We are making the general statement that the cost of concrete pavement maintenance through the years has been a lesser cost than the cost of maintenance of other types of pavement.

Mr. NELSON. I understand that. And we are trying to get at the proof of that statement.

This airfield that is 25 years old still in operation: Is that a military airfield or commercial airfield?

Mr. KENNEDY. That is a commercial airfield.

Mr. NELSON. Is it your contention, Mr. Kennedy, that an asphalt runway can't be built to take the load which modern aircraft require?

Mr. KENNEDY. The question that you raise is an involved one and gets into the basic questions of design of concrete and asphalt pavements.

There is a vast difference in the design principles that are involved in the design of a rigid pavement. We would not contend that a flexible pavement could not be built to withstand the loads that you stated.

Mr. NELSON. Your contention is, then, that the advantages of concrete are visibility and resistance to blast and spillage, aren't they? Isn't that the main contention?

Mr. KENNEDY. No, indeed. Those are a few of the arguments. The rest are those that I have stated and are contained in the brief: The matter of safety, the matter of visibility, the matter of snow removal and drainage, the problem of carrying and distributing loads, the problems of withstanding thrust and heat, and then all of the involved engineering problems of support from the soil beneath the pavement itself.

Concrete is superior because it has the ability to distribute the load over a wide area of the supporting soil.

Mr. NELSON. Do you have any other evidence otherwise than your unqualified statement, which I do not blame you for making representing the cement people, that asphalt pavements do not provide a proper stopping surface for airplanes?

Mr. KENNEDY. That asphalt pavements do not provide a proper stopping service——

Mr. NELSON. Surface.

Mr. KENNEDY. Concrete is better. It is more resistant to the movement——

Mr. NELSON. I wish you would answer my question. I know concrete is better. I know you will say that. But do you have any evidence that asphalt does not provide a proper stopping surface?

Mr. KENNEDY. There were a series of skid-resistance studies made by Moyer, of the University of California, relative studies as to the skid resistance of various types of pavements. Those showed exclusively that concrete has higher skid resistance than do other types of pavements.

I will be glad to furnish for the record those researches that were made by Moyer.

Mr. NELSON. We would like to have them. What was the difference?

Mr. KENNEDY. There was a rather substantial difference in the ability in the skid resistance of the various types.

Mr. NELSON. What was the difference, as measured by the test?

Mr. KENNEDY. Well, I do not have those figures at hand, but I will be glad to submit them for the record because they show a great distinction in the two types.

Another point I would like to make in that is the fact that the concrete pavement has uniform skid resistance wet or dry and that a big factor in safe operations, that it has uniformity to skid resistance.

Mr. HARDY. Will the gentleman yield right there?

Mr. NELSON. Yes, sir.

Mr. HARDY. Does that assume that you don't have any film of any kind on top of it?

Mr. KENNEDY. Well, Mr. Hardy, the construction of a modern concrete pavement for airport activities develops a finish that is distinctly rough in character, a coarse texture, so that the film that you refer to is not apt to gather on a modern concrete pavement.

Mr. HARDY. We might have to get a definition of the use of the word "apt" to understand that. But I don't know just how far we will get. Thank you, Mr. Nelson. You can take it up, if you will.

Mr. KENNEDY. The modern finish of a concrete pavement, Mr. Hardy, has a sandpaper quality, as you perhaps know.

Mr. HARDY. I have observed some of it.

Mr. KENNEDY. And doesn't have the smooth finish that roads built a quarter of a century ago may appear to have today.

Mr. HARDY. I would presume, however, Mr. Kennedy, that in take-off a jet might leave a little bit of film which over a period of time would accumulate. Isn't that a reasonable assumption, or not?

Mr. KENNEDY. Well, if that happened, sir, it might happen on either type of pavement.

Mr. HARDY. True enough.

Mr. KENNEDY. And the situation would be far worse with a pavement that did not have the texture that a concrete pavement has.

Mr. HARDY. I will turn it back to Mr. Nelson now, because we are getting to a point again where I would want something to support that statement.

Mr. KENNEDY. We will be glad to submit some data for the record on that particular point.

Mr. HARDY. I just want to be fair. I do think that you have to realize that some of the statements that you are making are based on a brand new surface, perfectly clean. Unless you assume that it will stay that way and will not get any film at all on top of it, which I don't believe. We are still talking about the braking surface or the stopping surface.

Mr. KENNEDY. The question, of course, is a relative one and is subject to the test that I have referred to made by Professor Moyer. They were made on pavements of various ages and show a decided difference between the skid-resistance qualities of concrete and other types. And I am going to submit for the record, if I may, those figures.

Mr. HARDY. I am still not sure that they would prove very much, unless we could have some evaluation of the relative cleanliness of them and the extent to which they are free from a grease film that sometimes does accumulate on surfaces. And I don't know how you would arrive at that.

Mr. KENNEDY. Well, if tests were made under similar application to both surfaces, the relative results would show the difference.

Mr. HARDY. You would assume that you were working on surfaces of the same age?

Mr. KENNEDY. Yes, sir.

Mr. HARDY. Having had relatively the same type of usage during the lifetime?

Mr. KENNEDY. Yes, sir.

Mr. HARDY. Their individual lifetime?

Mr. KENNEDY. Yes, sir.

Mr. HARDY. You might arrive at something that would reasonably be comparable in such a system. But I would want to know whether or not your tests were actually conducted in that manner.

Excuse me, Mr. Nelson. I don't mean to take it away from you.

Mr. NELSON. That is all right.

Mr. HÉBERT. May I ask a question, Mr. Nelson? [Laughter.]

Mr. KENNEDY. May I add one more point to Mr. Hardy's question? These tests that I have referred to were conducted on highways in operating traffic lanes. As you know, there is far greater likelihood of an oil film collecting on a traffic lane in which there is a high volume of traffic moving at all times than there is on an airport.

Mr. HARDY. Let me ask you this. Now, was that highway constructed with the same type—I am talking about the concrete part of it now—the same type of rough pavement that you are providing on your present air runways?

Mr. KENNEDY. I would say that the highways that were included in the test——

Mr. HARDY. Probably did not have quite as good a surface as you are putting on them nowadays.

Mr. KENNEDY. I would say yes. They probably not be equal to the skid resistance quality that the present airport——

Mr. HARDY. You are not doing yourself justice on that kind of a test.

Mr. KENNEDY. I don't want to overexaggerate. [Laughter.] The value and importance of concrete.

Mr. HARDY. We appreciate your modesty. [Laughter.]

Mr. HÉBERT. Mr. Kennedy, may I return to the question of those figures that we were discussing when we got off in two different directions here.

The question of maintenance: I asked if you had the figures to justify that, and you first offered figures of road maintenance over 28 years which you placed in the record.

Mr. KENNEDY. Yes, sir.

Mr. HÉBERT. And then you began to recite some figures of the Air Force, the Strategic Air Command and other sources in the Air Force. May I ask you where you got those figures from the Air Force?

Mr. KENNEDY. These are 1951 figures from the Strategic Air Command and could be verified through the Strategic Air Command.

Mr. HÉBERT. They gave them to you at your request? What I would like to know is how you came in possession of these figures.

Mr. KENNEDY. These figures were furnished to us upon request by the Strategic Air Command.

Mr. HÉBERT. Well, the reason I ask that question is because as I recall the testimony, when the Air Force was here, when the Secretary or Assistant Secretary was here and General Washbourne was on the stand, and others, the committee asked the Air Force for figures and the Air Force said they didn't have any valid figures. So I want to know how do you come up with the figures now?

Mr. KENNEDY. Of course, this is a problem that we have been studying for 25 years. I have a sheet here of other maintenance costs——

Mr. HÉBERT. Wait a minute. Let's stay right on the subject.

Mr. KENNEDY. Very well.

Mr. HÉBERT. Let's stay on the beam. We won't land very well, whether it is concrete or asphalt, if we don't. I have told you that the committee repeatedly asked the Air Force for figures on maintenance. The Air Force's reply, as far as my memory serves me, is that the Air Force said they had no valid figures. Now you present to the committee, in response to my question, figures which you say were furnished to you by the Air Force.

Now that is what I want to know, if—the Air Force testimony is that it has no valid figures and you then offered figures which you say are from an authority that says it has none.

Mr. HARDY. Maybe we ought to address that question to the Air Force.

Mr. HÉBERT. I am trying to find out. I will say one thing this hearing has produced: A lot of confusion, more than anything else. I am only trying to arrive at the facts.

Mr. KENNEDY. I think I can clarify that point very well, Mr. Hébert.

The testimony submitted by the Air Force, if I am correct, stated that the length of time in which the facilities had been in service under these modern conditions was such as not to be conclusive. In other words, we have had only 2 or 3 years of operation. We, therefore, would have to agree with the Air Force, that there isn't adequate information for final and conclusive determination of long-term maintenance costs, such as are available in other fields of pavement use.

These are study figures that we have worked with in working with the various branches of the Air Force. Our engineers throughout the country are constantly in contact with these problems.

Mr. HÉBERT. Now you are accepting these figures, then, or using them as the basis for a valid evaluation, when the Air Force tells you that they do not have any figures for a valid evaluation. And unless the question had been raised at this time when you were testifying, the committee would be left under the impression and the record would indicate that you were offering valid figures to which the Air Force subscribed, when as a matter of fact, the Air Force does not subscribe

to those figures as being valid or conclusive and it is only through the interrogation of the committee that it is brought to the committee's attention that this testimony is to back your case up.

Mr. KENNEDY. These figures, sir, are the best that are available at the present time and we believe in all honesty that they are representative of present-day conditions.

Mr. HÉBERT. May I interrupt you there, Mr. Kennedy?

Mr. KENNEDY. Yes, sir.

Mr. HÉBERT. Just in order to keep the questions and the answers right responsive. Nobody is denying that these are the best available figures. But you did not say that. You offered them as proof conclusive to the committee and until you were interrogated that impression was left to the committee, that you were giving us valid figures. That is all I am trying to do. I am not trying to arrive at the proof. I have no preference for asphalt or cement. I don't care.

Mr. KENNEDY. I realize that.

Mr. HÉBERT. It doesn't make any difference to me. But I think we would get far along if we didn't propagandize or advocate a cause to the detriment of the facts. That is all. I am just trying to get the facts here. I appreciate your position. If I were standing up there in your spot, I would be perhaps saying a lot more about concrete. But at least give us credit on this side of the table for knowing a little bit and not engaging in useless presentation and which we have to develop and take up your time and our time, when if you would state the facts I think we would all get along much better. Because when you really get down to it, nobody is going to dispute, as I told you in the opening statement, about the preferability or the preference of concrete over asphalt. Nobody will dispute the preference of diamonds over rhinestones. We are not disputing that. So why not admit it? And then begin on the basis of which is more economical, instead of trying to justify something with a lot of words, words, words, that we have to pursue to find what you mean that you are talking about.

I am sorry, Mr. Nelson. You have your baby back.

Mr. NELSON. Do I still have the floor, Mr. Chairman?

What was the trouble with concrete before you developed this air-entrainment program, Mr. Kennedy?

Mr. KENNEDY. Prior to air-entrainment in concrete, there occurred scaling of the surface of concrete in highway practice when deicing salts were used. Air-entrainment was developed initially in a part of the effort to counteract that scaling in pavements. And it has proven remarkably successful in doing so. And in doing so, it has also increased the workability in the placing of concrete and the durability of the finished product. It is an amazing improvement in the quality of concrete.

Mr. NELSON. How long have you had the program?

Mr. KENNEDY. How long have we had air-entrainment?

Mr. NELSON. Yes.

Mr. KENNEDY. From 1938 to 1940 was the period in which it was developed.

Mr. NELSON. Now, what evidence do you have, Mr. Kennedy, that on asphalt runways the wheels of the planes leave ruts and depressions—don't do it in concrete but you haven't said it does do it on asphalt. Does it? Is that your contention?

Mr. KENNEDY. My contention is that that does not occur, sir, in concrete, due to the very great hardness of the surface.

Mr. NELSON. But you are not saying that it doesn't occur on asphalt?

Mr. KENNEDY. No, sir.

Mr. NELSON. Well, then, where does that get us?

Mr. KENNEDY. Well, it is a great quality, of great importance to aircraft.

Mr. NELSON. You say it is an attribute that concrete has, and you don't say asphalt doesn't have it. So where are we?

Mr. KENNEDY. We are dealing with the best paving material for airport.

Mr. HÉBERT. Concrete, you mean?

Mr. KENNEDY. Yes, sir.

Mr. NELSON. You said that a JATO assist rocket doesn't damage concrete?

Mr. HESS. Mr. Kennedy, would you prefer to sit down? If you do, go right ahead.

Mr. KENNEDY. I rather enjoy being on my feet, Mr. Chairman. Observations to date do not indicate damage to concrete pavement from JATO.

Mr. NELSON. Mr. Kennedy, just one more question, if I may bring a long session to an end. Do you agree with the Air Force that concrete is only worth a 5 percent differential in cost?

Mr. KENNEDY. I think that the Air Force made a very strong case in behalf of the criteria that they have established. Naturally, I believe that a wider percentage could be used advantageously.

Mr. NELSON. Mr. Chairman, may I compliment the witness on a very diplomatic answer.

Mr. KENNEDY. Thank you, sir,

Mr. HESS. Are you finished, Charley?

Mr. NELSON. Yes.

Mr. HESS. Mr. Courtney.

Mr. COURTNEY. Mr. Kennedy, in order to give a proper evaluation to the difference in maintenance cost, whatever they may be and from whatever source derived, you would have to know the difference between the initial costs of the installation. Might there not be a situation in which one, for the low initial cost, could accept high maintenance and still be in a much more sound economic position?

Mr. KENNEDY. Yes. The answer to your question is most certainly "Yes," Mr. Courtney.

However, maintenance as normally defined, includes the maintenance operations themselves. We have for many years referred to the real cost involved as the low annual cost. And that includes a depreciating of the investment over the lifetime of the project. In other words, the cost of the project divided into the years of service gives you an annual cost for the capital investment. And added to that, the cost of annual maintenance gives the total annual cost. And for many years we have——

Mr. COURTNEY. Well, however you dilute it, Mr. Kennedy, you do get back to the fact that you must know initial costs first in order to make a true comparison.

Mr. KENNEDY. Indeed.

Mr. COURTNEY. That is all.

Mr. HESS. Would you have any figures, Mr. Kennedy, to show the depreciation on asphalt as against depreciation on cement, concrete? Just to give the life, for example. Do you have any figures?

Mr. KENNEDY. Oh yes. Again, if this is a valid presentation and meets with the acceptance of the committee, I would like to say that studies by the Highway Research Board and the Bureau of Public Roads indicate that the average life of concrete pavement is double that of the next high-type pavement.

Mr. HESS. Now, what about maintenance costs? Do you have anything on that?

Mr. KENNEDY. I am submitting, sir, if I may, a brochure which gives road surface maintenance costs gathered from 28 States, which we keep annually as a record. And this shows that——

Mr. HESS. Is that a different type of asphalt construction than the type of asphalt construction on runways or on airports? Isn't it a hot mix in the airports? And you might have this cold-type asphalt that they put on roads?

Mr. KENNEDY. Well, usually the high-type bituminous pavement of today used in highway work is also a hot mix.

Mr. HESS. The surface isn't though; is it?

Mr. KENNEDY. Yes, sir.

Mr. HESS. Is it?

Mr. KENNEDY. Yes, sir.

Mr. HESS. Well, now, do you have any comparable figures for airport construction? You have them for the highways. Of course, that gives us some idea.

Mr. KENNEDY. I don't think that the committee would hardly be willing to accept comparative data of this kind based on the examination that you have made of other figures. But in order to try to be helpful to the committee, may I point out that we have records of pavement life of 25 years, of concrete pavement, from the earliest airports that were built in this country up to the present day.

Here is a booklet that was published by our organization in 1930, showing the extent of airport paving as of that time. So that we have the record of the life of pavement over that period of time, a quarter of a century, but I am sure that Mr Hébert wouldn't be willing to accept that as evidence of the longevity of pavement to meet the furture jet age.

Mr. HÉBERT. Certainly——

Mr. KENNEDY. Knowing that we now have jet aircraft that has high temperatures and high blast and spillage and that we are developing experimental aircraft greatly beyond those and that in the future there is much that is yet to be done.

Mr. HESS. The committee, of course, will have to put a value on any of the figures you might present.

Mr. KENNEDY. Yes.

Mr. HESS. What I am driving at here, Mr. Kennedy, is to give us some figures so that we might sit down and attempt to ascertain which is the more economical insofar as the taxpayer is concerned.

Mr. KENNEDY. Yes.

Mr. HESS. Now we have had figures here to show that cement concrete construction in some instances is 60 percent higher than the asphalt construction. Now let's find out what the life of the concrete

is, what life of the asphalt is, and let's find the maintenance cost, and let's see if we can't arrive at a figure to decide whether or not one is more economical than the other to construct.

Mr. KENNEDY. Well, I think for actual facts, factual data, in that regard, that you would have to go to the Air Force.

If you would care for opinion, we could give you our opinion.

Mr. HESS. Go ahead. Give us your opinion on it. We would like to have that, too. You have had experience and you are engineers.

Mr. KENNEDY. We believe that the modern concrete pavement can take all of these improvements that have come along in the last few years, is going to have a tremendously longer life and render a greatly increased service for aircraft in the future. And we think that the ratio that has been shown in highways of 2 to 1 is not at all unrealistic as a comparable base for future activities.

Mr. HÉBERT. May I ask this, Mr. Chairman?

Mr. HESS. Yes.

Mr. HÉBERT. Mr. Kennedy, the figures you estimate on the highway maintenance and which you put out under your own stamp and approval. Does that brochure indicate where these figures come from?

Mr. KENNEDY. Yes, sir. Detail of each State——

Mr. HÉBERT. It comes from the State authorities?

Mr. KENNEDY. The State.

Mr. HÉBERT. And are assembled by your organization?

Mr. KENNEDY. Correct; that is correct.

Mr. HÉBERT. I mean the brochure shows that?

Mr. KENNEDY. Yes, sir.

Mr. HÉBERT. I just wanted that, to know for the evaluation to be placed on it.

Mr. KENNEDY. That is correct. And there will be copies made available to each of the committee members.

(The following was received for insertion at this point of record.)

[From Concrete Information, highways and municipal bureau, Portland Cement Association, August 1952]

ROAD SURFACE MAINTENANCE COSTS FROM 28 STATES

Construction costs occur only once for a paving project but maintenance is a continuing operation, year after year. Therefore, low surface maintenance costs are most important in obtaining low-annual-cost roads that are adequate for traffic. That portland cement concrete roads will have the lowest average annual surface maintenance cost is well established by the attached data from 28 States.

These are *all* the States which have kept maintenance cost records in sufficient detail so that surface maintenance costs can be segregated for each type. Not only are all such States covered but *every* year is shown for which costs are available. There have been no omissions nor deletions. Costs given for the individual State include all mileages under maintenance by State forces. In some cases this may cover not only the primary system but also the secondary system or portions of it.

To facilitate comparison, figures for each State are arranged and tabulated in similar form. No attempt has been made to convert the costs to dollar values with a common basis. Totals for each year represent the amount spent during that year to maintain each type.

The first table in the attached series summarizes the figures from the 28 States. The classifications of the various types follow the United States Bureau of Public Roads' most recent general classes. It will be noted that in the summary table all types of one class have been grouped in the general classification al-

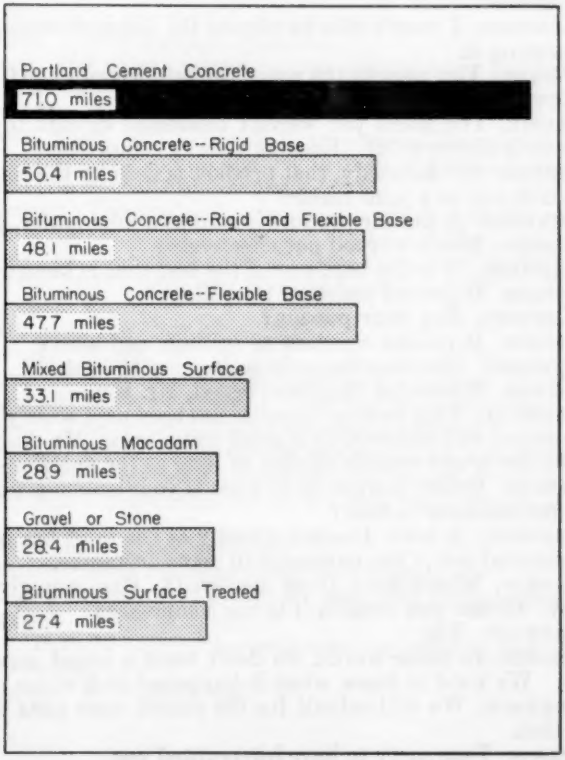
though some State tables carry two or more types of subclasses. For example, bituminous concrete on flexible base, USBPR Class I, in the summary table includes asphaltic concrete, rock asphalt and sheet asphalt. These are all placed in class I by the Bureau of Public Roads. Details for each State can be found in the individual State tables which follow the summary table.

Individual State tables cover all years available with a maximum of 30 years for Illinois. The majority of the tables have fiscal years ending December 31, 1950 or in 1951. However, there are four States for which costs have not been available since before World War II. These States explain that the manpower shortage has not permitted them to keep their detail records up to date. All States are shown in the summary table and weighted average costs were computed both with and without the four States.

The average period of service covered for the 24 States used in computing weighted averages is 20.8 years. This is sufficiently long to indicate clearly the trend of surface maintenance costs and to overcome the effect of periodic high costs. It is to be emphasized that in practically all cases these surface maintenanec costs do not include the periodic sealing or retreatment required by bituminous surfaces. This is shown specifically in the cases of Pennsylvania and Wyoming where notes on the tables give the added costs of such periodic maintenance. Undoubtedly the same situation exists in other States maintaining bituminous surfaces.

MILES OF ROAD SURFACE MAINTAINED FOR 1 YEAR WITH $10,000

Based on average surface maintenance costs from 24 States over a period of service averaging 20.8 years. Data were assembled from all States which have released detailed surface maintenance costs.



In considering surface maintenance costs, it should be borne in mind that most of the concrete pavements are on the main State highways and carry large volumes of heavy traffic. On other surfaces such as gravel, macadam, bituminous treated surfaces and bituminous surfaces the traffic is much lower. Should these surfaces be called upon to carry the same number and weight of vehicles as concrete, even for a short period, the surface maintenance costs doubtless would be increased.

States for which tables are attached are:

Arizona	Missouri	Rhode Island
Connecticut	Nebraska	South Dakota
Florida	Nevada	Tennessee
Illinois	New Jersey	Texas
Indiana	New Hampshire	Utah
Iowa	New Mexico	Washington
Kansas	New York	West Virginia
Kentucky	Ohio	Wyoming
Maine	Oregon	
Massachusetts	Pennsylvaia	

Mr. HESS. Any more questions, Mr. Hébert? Porter?

Mr. HARDY. I don't think so. I think I will give up.

Mr. HESS. Any more questions?

Mr. NELSON. Yes, Mr. Chairman. I think I know the answer, but I would like to ask the gentleman what he thinks about the product that was produced here this morning? Were you present when it was demonstrated?

Mr. KENNEDY. I wasn't able to witness the demonstration. I have no comment on it.

Mr. HÉBERT. You were in the room, though, weren't you?

Mr. KENNEDY. Yes, sir.

Mr. HARDY. You mean you weren't interested enough to come up and look at it afterwards? Even as a sorry competitor?

Mr. NELSON. Mr. Kennedy, that product is used by the cement contractors, is it not, as a joint sealer?

Mr. KENNEDY. A similar product is used as a joint sealer, yes, sir.

Mr. NELSON. Has it worked out effectively?

Mr. KENNEDY. It is the best, one of the best that is known today.

Mr. NELSON. It proved resistant to spillage?

Mr. KENNEDY. Beg your pardon?

Mr. NELSON. It proved resistant to spillage and blast?

Mr. KENNEDY. Resistant to spillage, but not to heat.

Mr. NELSON. Where has that been tested, Mr. Kennedy?

Mr. KENNEDY. That joining material has been used widely throughout the country and observed in a great many areas, Mr. Nelson.

I would like to say something else, as long as the question——

Mr. NELSON. Before you get off it, what is your evidence for the fact that it is not resistant to heat?

Mr. KENNEDY. A blast directed directly at the joint has blown the joining material out of the pavement in many instances.

Mr. NELSON. Where have those occurred? Can you give us the instances? Or can you furnish it to the committee?

Mr. KENNEDY. Yes.

Mr. NELSON. In other words, we don't want a broad general construction. We want to know when it happened and where and why.

Mr. KENNEDY. We will submit for the record some tests that were made on that.

Mr. NELSON. I am sorry to have interrupted you.

Mr. KENNEDY. May I talk a little more about joints?

The present practice in airport paving is not to build an integral joint at the time of the paving construction but to wait until the concrete has set and then to saw a joint in the paving. This gives a uniform hard texture across the joint and then joining material is put in under pressure.

This is a new method of building joints that is now recognized as almost standard practice and represents another great improvement in the technology of pavement construction.

Mr. NELSON. Is this the best joint filler that you have for concrete so far?

Mr. KENNEDY. There are various proprietary materials that have been under test. This is one of the better.

Mr. NELSON. Do you have any joint filler that won't blow out on a blast?

Mr. KENNEDY. No.

Mr. NELSON. So that it is a little difficult with concrete, isn't it?

Mr. KENNEDY. Well, it is one of the problems that is comparable with the use of other types of pavements. It occurs to a very minor degree in connection with concrete pavement and it is a problem that is being studied and a great deal of research work done on it. I have every confidence that it will be a—that great improvements will be made in that area in the not too distant future.

Mr. NELSON. I have no more questions.

Mr. HARDY. If I might return to that same subject for just a second, Mr. Chairman.

Mr. HESS. Mr. Hardy.

Mr. HARDY. Then, Mr. Kennedy, your observation originally, that this material did not stand up against heat—you were referring more to blasts than you were to heat; is that right?

Mr. KENNEDY. The heat—it softens under heat and the condition of the blast is the condition that brings the heat to the joint.

Mr. HARDY. So your contention is, then, that actually the cause of its blowing out of the joint was that the heat had softened it up?

Mr. KENNEDY. Right.

Mr. HARDY. And the blast blew it out?

Mr. KENNEDY. Right.

Mr. HARDY. Well, that would happen with any kind of a filler, is that right, unless it were concrete? And you haven't a concrete that you can use as a filler because of the expansion coefficient?

Mr. KENNEDY. Experiments now in progress with asbestos cementing materials indicate that a proper joining material can be found that will be much more resistant to the heat and therefore to the blast.

Mr. NELSON. How about spillage?

Mr. KENNEDY. Well, the same thing would apply.

Mr. HESS. Thank you very much, Mr. Kennedy and gentlemen.

Mr. KENNEDY. Thank you, sir.

Mr. HESS. Is there any further evidence you want to give the committee, or information?

Mr. KENNEDY. No, I think not.

Mr. HESS. If not, why, we thank you very much for coming here.

Let me make this statement at this time. This concludes the number of witnesses I believe, Mr. Courtney; is that correct?

Mr. COURTNEY. Yes.

Mr. HESS. We did say at the outset, however, that if anybody wants to file with the committee any other data that they might have, why, we are perfectly willing to have them file it and will make it part of the record.

So if the asphalt people or any of the services have any other data that they want to file or the concrete people, why, we will be glad to make it part of our record.

Mr. COURTNEY. Mr. Chairman, may I make this request, that since the record is being held open and since there are or may be some people who would desire to file additional statements or even corrected statements, that we agree that the record will remain open until one week from today. There is data to be supplied by the Asphalt Institute and also by the Portland Cement Association. And there is also data to be supplied by the Government Testing Laboratories and some of their principal advisers.

Mr. HESS. Very well.

Mr. COURTNEY. That will go into the record this coming week.

Mr. HESS. The record will be held open, then, until the 12th of February.

Mr. COURTNEY. Until the 12th of February.

Mr. HESS. If there is anybody that wants to file any statements, why, put them in Mr. Courtney's hands before the 12th.

The committee will adjourn subject to the call of the Chair.

(Whereupon, at 3:20 p. m., the committee adjourned, subject to the call of the Chair.)

AIRSTRIP PAVING MATERIALS

MONDAY, FEBRUARY 8, 1954

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON DEFENSE ACTIVITIES OF THE
COMMITTEE ON ARMED SERVICES,
Washington, D. C.

The subcommittee met at 10 a. m.

Mr. COURTNEY. Gentlemen, what we want is the results of your tests and investigations from time to time. I think you have made some, haven't you, Colonel?

TESTIMONY OF H. B. ZACHRISON, CHIEF, ENGINEERING DIVISION, MILITARY CONSTRUCTION, ACCOMPANIED BY GAYLE McFADDEN, CHIEF, AIRFIELDS BRANCH, ENGINEERING DIVISION; COL. HERMAN ORR, MILITARY CONSTRUCTION FIELD GROUP; AND B. U. DUVALL, OHIO RIVER DIVISION LABORATORIES

Mr. MCFADDEN. I am Gayle McFadden, Chief of the Airfields Branch, Engineering Division, in the Office of Chief of Engineers, Department of the Army.

Mr. COURTNEY. And how long have you been with the Chief of Engineers?

Mr. MCFADDEN. About 24 years.

Mr. COURTNEY. What is your technical training, Mr. McFadden?

Mr. MCFADDEN. I have been continuously engaged in engineering for the past 40 or more years. My engineering education was obtained at the Alabama Polytechnic Institute, better known as Auburn. I have been with the Corps of Engineers since 1932. I have been continuously engaged in airfield work since 1937.

Mr. COURTNEY. And you are a member of the American Society of Civil Engineers?

Mr. MCFADDEN. Yes, sir; and a registered professional civil engineer.

Mr. COURTNEY. You keep abreast of the literature of your profession?

Mr. MCFADDEN. Yes, sir.

Mr. COURTNEY. And you have contributed from time to time to technical journals on the subject of your work with the Corps of Engineers?

Mr. MCFADDEN. Yes, sir.

Mr. COURTNEY. Mr. McFadden, the subject of this inquiry is the recent directive of the Air Force establishing criteria for runway pavement.

And I would like, if you would, please, to give us the benefit of your experience and your observations with the Corps of Engineers on the use and adaptability and maintenance experience, if you have that within your knowledge, of asphalt pavement, and then of concrete.

Now you just start out in your own way, if you will, please.

Mr. McFadden. Well, I have always held to the opinion, Mr. Courtney, that structurally there is no difference between asphalt pavements and portland cement concrete pavements, properly designed. I say properly designed would apply to both of them.

Recently, with the advent of the jet plane, there is still no question as to the structural equality.

There has been some question as to their performance. We have gone into that very thoroughly. We have extended our investigation work with the idea in mind of trying to design a flexible-type pavement, that is an asphalt pavement, that would serve the usage of jet aircraft.

I believe that at the present moment an asphalt pavement is generally equivalent to portland cemenet concrete pavement for the usage today, under normal operation of jet aircraft.

There is no question in our minds that some damage occurs by continued and excessive spillage of fuel on an asphalt pavement. We would be in a rather untenable position if we said that, because we know the fuel and the asphalt comes from the same parent stock. Therefore they have an affinity for each other and there will be some softening effect. But our experience is that this softening effect is somewhat temporary, that if let alone or reasonably alone the pavement will reharden again to its original condition.

I have seen areas where there is material damage done to asphalt pavements under the action of jet aircraft. I have seen other pavements that were not materially damaged at all.

Mr. Courtney. Does the climatic conditions have anything to do with the extent of the damage?

Mr. McFadden. Somewhat, because of the fact that the fuel is a volatile matter and the ambient atmospheric temperature has a lot to do with how fast it evaporates. So the climatic conditions do have something to do with it.

Also, a great deal to do with it is, how this pavement is designed and constructed.

Mr. Courtney. Well, may I break in right there? Now when you say the climate has something to do with that, would I be correct in assuming that the more rapid the evaporation the less damage to the payment?

Mr. McFadden. Yes, sir; that is my opinion

Mr. Courtney. And, of course, the contrary premise would be true.

Mr. McFadden. That is right.

Mr. Courtney. Now, if you will carry on from there?

Mr. McFadden. As I started to say, I think probably the design and construction of the pavement has more to do with its resistance to the effect of fuel spillage than maybe the climatic conditions. We have done a lot of experimentation along that line. We have come to the conclusion that a dense, well-graded mixture will resist fairly satisfactorily the spillage of fuel. I say fairly satisfactory. I mean by satisfactory under normal operation of jet operation.

Mr. COURTNEY. Now, where do you draw the line when you say normal operation?

Mr. MCFADDEN. Well, I would say the landings and takeoffs and perhaps the normal fuel.

However, if a plane is allowed to just stand in one position with the tanks overflowing, with pools of fuel standing around it, there is no question about it that the pavement will soften and the degree in which it softens will be in direct proportion to the amount of spillage that is allowed to stand and continue to drain on the pavement.

Mr. COURTNEY. Well, is this, then, a correct summary of what your opinion is, that if normal operational methods are employed and planes are taking off and return at scheduled intervals, regularly scheduled intervals, that that is what you are speaking of?

Mr. MCFADDEN. Yes, sir.

Mr. COURTNEY. As normal operations?

Mr. MCFADDEN. Yes, sir.

Mr. COURTNEY. And that under those circumstances there will be a reduced amount of spillage?

Mr. MCFADDEN. That is right.

Mr. COURTNEY. As distinguished from carelessness, where spillage is allowed to accumulate and saturate any given point?

Mr. MCFADDEN. That sums it up; yes, sir.

Mr. COURTNEY. Now, Mr. McFadden, what about the effect of blast?

Mr. MCFADDEN. Well, I have never seen any particular damage from the blast effect of aircraft, Mr. Courtney.

Mr. COURTNEY. Of course you are speaking now of asphalt?

Mr. MCFADDEN. Yes, sir.

We are still talking about that.

Except where perhaps the blast has been allowed to blast at 100 percent or full power run up over an abnormal, long period of time.

Now, about a year or a year and a half ago, perhaps it is closer to 2 years ago now, we conducted some experiments down at Eglin Field, with full cooperation of the United States Air Force, to determine the effect of blasts on both kinds of pavements. We built a series of panels down there. I believe there were 12 panels of asphaltic concrete and 12 panels of portland cement concrete. We subjected those panels to the heat and blast effects of every type of jet aircraft known at that time. I believe that would still prevail. I don't believe there are any new ones in the air since that time. Before we subjected the panels to this blasting effect, we determined what would be a reasonable length of time in which it would be subjected to the blast. That was done by sending a party around to various fields throughout the country that habitually used jet aircraft. This party was composed of not only personnel from the Corps of Engineers but personnel from the Air Force, in order to get an unbiased study.

Based on that study and the timing of the movement of aircraft on these different fields, a chart was set up which determined the time of exposure for the blast effect to these panels.

As a result of those tests, we did not find any appreciable damage from the heat and blast effect of jet aircraft.

(At this point the Honorable Charles P. Nelson entered the hearing.)

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Mr. COURTNEY. Now, I have two questions about that experimentation, Mr. McFadden.

In constructing this panel, did you employ a different method or a different design for various panels, so that you would have a comprehensive test, if you please?

Mr. MCFADDEN. No, sir. They were all constructed under the same specifications.

Mr. COURTNEY. On the same specification?

Mr. MCFADDEN. The same quality of pavement in each case.

Mr. COURTNEY. And you say there were about 12 of each?

Mr. MCFADDEN. Yes, sir.

Mr. COURTNEY. Both concrete and asphalt?

Mr. MCFADDEN. And asphalt.

Mr. COURTNEY. Now, there has been testimony here that the Navy jet takes off at a more acute angle than that of the Air Force jet, for which reason the Navy says that it reduces its requirements for the concrete at the end of the strip from 1,000 feet to 500 feet.

Now, did you have any occasion to examine into any of the Navy installations for damage at the end of the strip?

Mr. MCFADDEN. No, sir; I have never examined any Navy installation.

Mr. COURTNEY. Your inquiry has been directed solely to the use of Air Force jet planes?

Mr. MCFADDEN. That is correct.

Mr. COURTNEY. Now as to the time at which this experiment was run, Mr. McFadden?

Mr. MCFADDEN. It was in January 1952.

Mr. COURTNEY. Has there been to your knowledge any change in the type of aircraft or its operation or the amount of spillage, if you know, by reason of any refinement in jets?

Mr. MCFADDEN. Not to my knowledge.

Mr. COURTNEY. So that the aircraft you were dealing with in your opinion in 1952 would be substantially the same as that of the present state of development?

Mr. MCFADDEN. As far as I know.

Mr. COURTNEY. Now, I think that experiment to which you have just addressed yourself was referred to and published in some scientific data or journal; was it not?

Mr. MCFADDEN. That was published to a large extent in a symposium held by the Navy out at Port Hueneme. I believe that was April 1952.

Mr. COURTNEY. The discussions taken place have been generally circulated among the service personnel, have they not?

Mr. MCFADDEN. Yes, sir. I understand there is quite a large publication.

Mr. COURTNEY. I believe you also published data in the Military Engineer and perhaps some other scientific journal?

Mr. MCFADDEN. I had one article in the Military Engineer which was a summation of this data that was published in the Navy Symposium. And I have published an article in the proceedings of the American Society of Civil Engineers.

Mr. COURTNEY. And those were published about August of 1953, or the fall of last year?

Mr. McFADDEN. The paper in the American Society of Civil Engineers was given in March of last year and was published somewhat in the fall of 1953.

Mr. COURTNEY. The question, then, is this: Is there anything that has occurred in the interval between the accumulation of this data and the publication of your opinions which would alter in any respect the conclusions which you have reached?

Mr. McFADDEN. No, sir; I don't know of anything.

Mr. COURTNEY. Now, does your work require you to keep abreast of developments in this field?

Mr. McFADDEN. Yes, sir.

Mr. COURTNEY. Do you have any other duties that would interfere with giving your attention to that subject?

Mr. McFADDEN. That is part of my job. We try to get the information from the Air Force to keep us current upon the different types of aircraft in which we have designed pavements.

There is only one thing that might occur that might influence that, and that is the introduction of the afterburner to the jet aircraft.

Now to what extent that afterburner is used I am not in position to say.

Mr. COURTNEY. Well, is that a new development, a relatively new development, Mr. McFadden?

Mr. McFADDEN. That is a development since those tests which I have just described; yes, sir.

Mr. COURTNEY. What is the afterburner and what does it do, as you know?

Mr. McFADDEN. I am not in position to give you a complete technical description of that, Mr. Courtney. An afterburner is a booster, as I understand it, to the jet engine which creates a rather intensive heat movement area.

Mr. COURTNEY. You don't know whether it would subject the runway to spillage?

Mr. McFADDEN. I don't think it has anything to do with spillage. Mr. Duvall is perhaps more acquainted with that afterburner detail than I am.

Mr. COURTNEY. Then, sir, we will pass that to Mr. Duvall.

Mr. McFADDEN. Yes, sir.

Mr. COURTNEY. We will take you in your turn, Mr. Duvall.

Now, did you have anything to do with the installation at Thule?

Mr. McFADDEN. No, sir.

Mr. COURTNEY. The Corps of Engineers built that installation, did it not?

Mr. McFADDEN. Yes, sir.

Mr. COURTNEY. And I think it is fairly recent, is it not?

Mr. McFADDEN. Yes, sir; it is fairly recent.

Mr. COURTNEY. Are you familiar with that installation?

Mr. McFADDEN. I have never been there, sir.

Mr. COURTNEY. Do you know about the installation in the Azores?

Mr. McFADDEN. I have never visited that.

Colonel ORR. I am.

Mr. COURTNEY. All right. What about Hickman Field?

Mr. McFADDEN. I haven't been to Hickman Field.

Mr. COURTNEY. Keflovik.

Mr. McFADDEN. I have never been to Keflovik.

Colonel ORR. I have been there.

Mr. COURTNEY. Hickman, of course, is not new and neither is the Azores, but Keflovik and Thule are relatively new.

Could you tell us about how many fields that you personally have examined?

Mr. McFADDEN. You mean regardless of whether they were subjected to aircraft or not, or just an open field?

Mr. COURTNEY. Yes, sir; in the course of your studies of damage.

Mr. McFADDEN. I pretty well covered the country, sir; that is, the continnental limits of the United States, from one end of the country to the other. I visited and inspected fields from Maine to California and from the State of Washington to Florida.

Mr. COURTNEY. Are you familiar with the field at Limestone, Maine?

Mr. McFADDEN. Yes, sir.

Mr. COURTNEY. What is the fact so far as your observation is concerned as to the extent of jet operations from that field?

Mr. McFADDEN. I have never been there since they started using jets.

Mr. COURTNEY. You haven't?

Mr. McFADDEN. No, sir.

Mr. COURTNEY. Now, as an engineer, conceding for the moment damage from spillage—let us distinguish spillage from blast as that is what everybody seems to do—what is the nature of the damage that occurs, and how extensive is, and what problem of repair and maintenance does it pose, making the assumption that there is damage?

Mr. McFADDEN. Well, the damage from the 2 types of action from jet aircraft, namely, the heat and blast and the spillage of fuel, are 2 entirely different things. As I said, the heat and blast, so far as I have been able to observe, is minor in character. It may cause some slight charring of the surface or if subjected to long enough exposure it is quite probable that after being charred, the blast effect would erode some of the material from the top. I think that those areas are necessarily small in extent. There they would only be a few yards long by a few yards wide. They could be readily cured by a surface treatment of asphalt with a cover coat of mineral aggregate.

Mr. COURTNEY. Is that either an extensive or an expensive operation?

Mr. McFADDEN. No, sir. I would say that is a normal maintenance operation.

Mr. COURTNEY. And as to the cost of performing such work?

Mr. McFADDEN. The cost of that would be very minor.

Mr. COURTNEY. What about the method employed? Would it be possible to do that with field personnel?

Mr. McFADDEN. It should be. It is common; it is a common method of repair. And every organization who has the responsibility for maintenance should have the equipment to do it.

Mr. COURTNEY. And is it your experience that generally those fields do have such equipment?

Mr. McFADDEN. That would be the experience as to the heat and blast effect. I think if you go to spillage, you have another condition there.

You would get, as I have said before, a temporary softening of the surface. If it is subjected to quite an intensive use directly after the

spillage of the fuel and while the pavement is still soft, you would probably have some distortion of the surface.

If it is allowed a reasonable time to recuperate, I don't think you would have that.

In those extreme cases you would probably have the dilution of the binder material that holds the aggregate together. That could be restored by a surface treatment, as I have described for the other.

Mr. COURTNEY. Now, there has been some testimony here, Mr. McFadden, that the surface after blast or fuel spillage has loose material, the aggregate which is released from its binder, and that that will be sucked up into the jet and damage the blades in the jet. Have you made any observations along that line?

Mr. MCFADDEN. I have never seen any loose particles as a result of that, any more than other loose particles you would find on the pavement. You will find dirt and pieces of rock or other debris on the pavements from time to time. In some rare cases you will find an excess amount of loose material in there, where it is subjected to a more than normal use. But normally I don't think I have seen any excess of loose material around those spots.

Mr. NELSON. You have that loose material on both asphalt and concrete?

Mr. MCFADDEN. Yes, sir.

Mr. Zachrison makes a point there which I agree to, that it could be loosened by blast.

Mr. COURTNEY. It could be loosened by blast?

Mr. MCFADDEN. Yes.

Mr. COURTNEY. I notice you make a distinction, and I refer again to that, between what you call normal operations and the damage from blast in normal operations. Is that because of the speed of the aircraft in takeoff?

Mr. MCFADDEN. No, sir, I make that distinction between normal operation and other than normal operation as a matter of my observation of housekeeping on the post or a matter of field discipline. If the personnel on a post are permitted to be careless with the use of fuel or the places they park these planes, you are going to have greater damage than at a well-disciplined place where the personnel are required to fuel with some care.

As an illustration of what I am trying to say, normally as against abnormal operations, about a year and a half ago when I visited March Field a B–47, which was one of the late types of jet aircraft, had been parked in that place and I asked the resident engineer to take me out to the asphaltic apron and let me look and see what happened. I knew asphalt pavement and I wanted to see. I went out and he showed me where it had been parked and where it had been fueled and while there was some stains on the pavement there was no softening. I had to get practically down on my hands and knees to see where the airplane had driven across it, where the char marks were, they were so indistinct. I made a remark to the resident engineer that there was no damage to this pavement, I believed, and he said "Unless you come over to this spot," and he took me down to a place about 15 feet from the edge of the apron where the tank truck, instead of draining the hoses back into the tank, had drained the excess fuel from the hose all over the pavement. I don't think that is normal operation. I just

draw that to make that illustration to show what I mean by normal and not normal operation.

Mr. NELSON. May I interrupt right there?

Then in your opinion, Mr. McFadden, most of the damage by spillage could be obviated by good housekeeping?

Mr. MCFADDEN. I say a great deal of it could, sir.

Mr. COURTNEY. Now, Mr. McFadden, on the subject of concrete and damage on that type of pavement (1) as to spillage and (2) as to blast, what is your opinion from the observations you have made?

Mr. MCFADDEN. I have never seen any damage to a concrete pavement either from blast or from spillage, except to the joint sealing material.

Mr. COURTNEY. Now of course as a practical matter, again as an engineer, the difference of course would be in cost of the original installation.

Mr. MCFADDEN. That is right, sir.

Mr. COURTNEY. And that would be the target to which you are addressing yourself and in trying to accommodate yourself?

Mr. MCFADDEN. Yes, sir.

Mr. COURTNEY. As an engineer and as a builder?

Mr. MCFADDEN. That is right.

Mr. NELSON. Mr. McFadden, as I understand from the testimony of the Air Force, they have transferred to the Corps of Engineers upward of $5 million for research on pavings?

Mr. MCFADDEN. No, sir—you mean altogether, up to now?

Mr. NELSON. Yes.

Mr. MCFADDEN. I expect that might be a fair figure, sir. I haven't added it up, but that sounds right. It might be reasonable. We get from them for investigation work in the field of pavements somewhat, a little less than about I should say three-quarters of a million dollars a year.

Mr. NELSON. And you use that money in the experiments you have made on pavement?

Mr. MCFADDEN. Yes, sir.

Mr. NELSON. Now, prior to the issuance of the Air Force policy directive defining critical areas, which I assume you are familiar.

Mr. MCFADDEN. Yes, sir.

Mr. NELSON. Did you make any recommendations to the Air Force as to the definition of critical areas?

Mr. MCFADDEN. Yes, sir. On two occasions we have recommended what pavements should be included in the critical category.

Mr. NELSON. Do you have any copies of those recommendations or can you give them orally?

Mr. MCFADDEN. No. We have letters in the file at the office, sir. I don't believe I have them with me.

Mr. NELSON. Could we have those recommendations for the record?

Mr. COURTNEY. For the record, then, your final recommendations or whatever they may have been?

Mr. MCFADDEN. Well, we recommended that the critical areas be designated as the areas around the refueling points and for maintenance aprons.

Mr. COURTNEY. And for maintenance aprons?

Mr. MCFADDEN. Yes, sir.

Mr. NELSON. But you did not recommend that the end of the runway be designated as critical areas?

Mr. MCFADDEN. No, sir. We did that in 1952 and in our last recommendation, last year, we omitted that recommendation of runway end.

Mr. NELSON. Well, in the opinion of the full Corps of Engineers, should the ends of the runways be designated as critical?

Mr. MCFADDEN. I don't think so, sir.

Mr. NELSON. Does the Air Force have around the ends of runways so-called blast pads or something like that?

Mr. MCFADDEN. That is standard practice now and we are constructing the blast pavements around the ends of runways.

Mr. NELSON. What are those blast pads constructed of?

Mr. MCFADDEN. You mean the composition of them, sir?

Mr. NELSON. Yes. Are they asphalt or concrete?

Mr. MCFADDEN. They are 6 inches of stabilized base and 2 inches of concrete.

Mr. NELSON. How have they been standing up?

Mr. MCFADDEN. That is a fairly recent innovation, and I haven't seen how they are standing up in use anywhere they are in operation.

Mr. NELSON. Those blast pads are located where they would be subjected to blast as much as anywhere on the airfield?

Mr. MCFADDEN. They were put there for that purpose, sir.

Mr. NELSON. And you have not received any complaints or no complaints have been referred to you by the Air Force?

Mr. MCFADDEN. No, sir.

Mr. NELSON. Now, Mr. McFadden, have you examined any airfields upon the basis of the complaint coming from the Air Force?

Mr. MCFADDEN. Yes, sir; we have investigated or caused to be investigated every complaint that has been received from the Air Force as to the deterioration of pavements under the effect of jet aircraft. We haven't done it all from this office. Some of them were referred to our field offices for investigation. Some of them have been investigated by our office.

Mr. NELSON. And could you give us the results of the investigations you made?

Mr. MCFADDEN. I should say you could sum it up generally, sir, that we have found no appreciable damage to those pavements that have been reported to us as being severely damaged.

There are 1 or 2 minor exceptions. Let's say that all flexible type of asphalt pavements that have been designed by a current method, which produces a dense surface and composed of a well-graded mix, have shown little or no deterioration. Those pavements, older pavements, that were built prior to our investigations leading to a better pavement have shown some deterioration.

Mr. NELSON. Was that also built prior to the advent of jets in any quantity?

Mr. MCFADDEN. Yes, sir. They have shown some deterioration under the action of jet aircraft, that is the older pavements built under the older criteria.

Mr. NELSON. Those were pavements that were not especially designed to accommodate jet aircraft?

Mr. MCFADDEN. That is right, sir.

Mr. NELSON. In the course of your investigation, have you found any damage at all to runways due to blast?

Mr. MCFADDEN. I can't recall of any report we have had of these investigations of these specific cases where damage to a runway was reported, in any appreciable extent. There may be some spotty or minor distress in the pavement, but in general, no.

Mr. NELSON. Is it a policy between the Air Force and the Corps of Engineers, that you receive all complaints with regard to runway that are made?

Mr. MCFADDEN. I don't think we receive all of them, sir. We receive quite a few.

In running hastily through my records in the last 2 or 3 days, I find a case of about 21 instances where they have reported material damage to pavements as a result of jet aircraft operating on them. We have investigated each and everyone of those 21.

Mr. NELSON. And you have found only minor damage?

Mr. MCFADDEN. Very minor. I would say minor damage would cover the general summary of our results.

Mr. NELSON. Well, would you for the record say what you mean by minor damage?

Mr. MCFADDEN. Well, I would say, as I have explained here, that there would be some isolated spots of comparatively small area that would probably need some repair. But taking a runway as a whole, I would say that the area that would need this repair would be extremely minor or very small percentage of the whole.

Mr. NELSON. These 21 complaints that you investigated were all complaints of damage to asphalt construction?

Mr. MCFADDEN. That is right.

I would like to qualify that statement in one way, sir. There is one field that we agree was badly constructed and the damage greater.

Mr. NELSON. That is Williams?

Mr. MCFADDEN. Williams. I think we are all familiar with that. I wanted to get that in the record, that I didn't say that all we examined were clean.

Mr. NELSON. In the opinion of the Corps of Engineers that was due to faulty original construction?

Mr. MCFADDEN. That was due to construction and not design. It wasn't design fault. It was construction fault.

Mr. NELSON. Now, of the 21 complaints which you investigated would you break them down as to the category of damage—that is, as between spillage and blast?

Mr. MCFADDEN. These were practically all from spillage.

We have had maybe 1 or at the most 2 complaints from blast. One was at McChord. That is in the State of Washintgon. As far as I can recall offhand, that is the only one we have had any complaint as to blast. The rest of them were as a result of spillage.

Mr. NELSON. And these 21 complaints all pertained to fields that were constructed before the advent of the jet aircraft?

Mr. MCFADDEN. No, sir; I don't think I can say that.

Mr. NELSON. Then, how many?

Mr. MCFADDEN. I can't say offhand, sir. I would have to look that up. I don't know.

Mr. NELSON. Would you furnish the committee with that information?

Mr. McFADDEN. I will try to do that; yes, sir.

Mr. NELSON. Now, in your article, which I assume you wrote for the Military Engineer, May-June 1953——

Mr. McFADDEN. I wrote an article which was published in the Military Engineer about that time.

Mr. NELSON. Well, I quote from the article as published:

> Only the starting operation on the apron, the pretake-off check at the end of the runway, and the maintenance runup are critical from the standpoint of heat and blast because the planes are in motion during other operations and temperatures do not build up.

Mr. McFADDEN. Yes, sir.

Mr. NELSON. That is accurate and true?

Mr. McFADDEN. Yes, sir; I think that is an accurate statement.

Mr. NELSON. So you would not expect that you would have any damage on the runway from the operation of jets?

Mr. McFADDEN. Not from the operation of jet aircraft. As I said before I am not prepared to testify as to what effect an afterburner might have.

Mr. NELSON. Will the Corps of Engineers, however, continue these experiments?

Mr. McFADDEN. We are continuing them; yes, sir.

Mr. NELSON. The purpose of an afterburner, if you know, is just as a booster to give additional pounds of thrust; is it not?

Mr. McFADDEN. That is my impression, sir.

Mr. NELSON. But you think it might build up additional heat from the aircraft that you have experimented with?

Mr. McFADDEN. I don't know to what duration the afterburner would affect the pavement.

I don't know. It depends on whether that afterburner is in effect, and whether the plane is standing still or whether it is in motion.

Now if it is a booster and it is only cut in after the plane is in motion, probably most of the heat would be dissipated.

Mr. NELSON. Now I go on to quote from your article, if I may.

You are summarizing the results of your test. And in paragraph No. 5 you say:

> Only minor damage of asphaltic concrete pavement occurred in jet blast when the termperature reached 300°. At lower temperatures there was no damage and somewhat higher temperatures were required to cause any appreciable damage.

Mr. McFADDEN. Yes, sir.

Mr. NELSON. Do I understand from your testimony that so far as you can recall you had only one complaint as to blast damage at McChord Field?

Mr. McFADDEN. That is the only one I recall at the moment, sir.

Mr. NELSON. What temperature do these jet planes generate in the critical areas?

Mr. McFADDEN. The temperature would have to be measured there, sir, at the temperature of the surface of the pavement. It will create different temperatures at different positions. The degree of temperatures depend upon the position at which you measure it.

Mr. NELSON. The thing we are interested in is the temperature generated at the surface of the pavement.

Mr. McFADDEN. Yes. As I recall from those tests we conducted at Eglin Field, the maximum temperature that we recorded at the surface of the pavement, and that was after a 21-minute exposure, was 385°, I think.

Is that right?

Mr. DUVALL. Yes.

Mr. McFADDEN. 385° F.

Mr. NELSON. Now, does that damage asphaltic concrete pavement?

Mr. McFADDEN. That eroded to a small degree, after 21 minutes of blast.

Mr. NELSON. After 21 minutes of blast?

Mr. McFADDEN. Yes, sir.

Mr. NELSON. And in normal practice the pavement would never be subjected to such extreme blast?

Mr. McFADDEN. That 21 minutes of blast, sir, was 50 percent in excess what we considered as normal at the time we made the survey.

Mr. NELSON. As I recall the testimony you were giving when I came in, you said that in the instances that you had investigated the damages were only minor and just a routine matter for repair?

Mr. McFADDEN. That is my opinion, sir.

Mr. NELSON. Are you acquainted with the air base at Plattsburg or the contract that was let at Plattsburg?

Mr. McFADDEN. In what way, sir?

Mr. NELSON. Are you acquainted with the Air Force definition of pavement as it was let in that contract?

Mr. McFADDEN. No, sir; I don't believe I am.

Mr. NELSON. Would you tell me what the Corps of Engineers' definition of pavement is?

Mr. McFADDEN. Well, I would say that a pavement is any part of that structure upon which an aircraft rides above a subgrade.

Mr. NELSON. Then, if a criteria is adopted allowing a 5-percent differential as between concrete and asphaltic concrete, you think only the pavement should be considered in arriving at that differential?

Mr. McFADDEN. I would say that we would only consider that part of the pavement structure above the subgrade, which would not include any drainage, embedded items, or grading.

Mr. NELSON. On the basis of the reply you just made you don't think it would be fair to include the relocation of a railroad?

Mr. McFADDEN. I hardly think so, sir.

Mr. NELSON. Now, Mr. McFadden, would you mind repeating what the Corps of Engineers considers a critical area on an airfield?

Mr. McFADDEN. Well, our last recommendation, sir, for the designation of critical areas, would be the area around the fueling points and the maintenance aprons.

Mr. NELSON. And that is because of damage from spillage or possible damage from spillage?

Mr. McFADDEN. The reason for that was around the fueling aprons we are not too satisfied that you can control the apparatus of fueling, which would absolutely eliminate any abnormal spillage, so we figure that there will be sufficient spillage around those areas to keep that pavement more or less at a continuous softened state.

As far as the maintenance apron is concerned, there, again, it is a matter of housekeeping. We have had complaints from the Air Force that not only the fuel but other solvents used in maintaining

and cleaning airplanes when they get on the pavement will produce some softening, which could be picked up with the feet and tracked into the airplane and hangar.

In an effort to be fair and to obviate such a condition as that, we also specified the maintenance apron.

Mr. NELSON. In other words, you think, as I understand your testimony, that a good deal of the damage by spillage could be eliminated by good housekeeping?

Mr. MCFADDEN. That is my opinion, sir.

Mr. NELSON. You feel that some spillage is going to occur and to be safe those particular areas should be built of concrete?

Mr. MCFADDEN. In those two areas we are quite sure that more than normal spillage would occur.

Mr. NELSON. What percentage of an airfield would that area represent?

Mr. MCFADDEN. That is rather hard to determine—the percentage—because the areas of pavement fluctuate so greatly. Let's say it would be a comparatively small percent.

Mr. NELSON. You think the Corps of Engineers is perfectly competent and qualified to design new airfields to meet the specifications given by the Air Force out of asphalt?

Mr. MCFADDEN. I think that we are competent to design any structure that will fulfill their functional requirements, sir. I wouldn't argue with what their functional requirements are, but we will meet them if they give them to us.

Mr. NELSON. That is all I have, sir.

Mr. COURTNEY. Mr. McFadden, there has been testimony here with respect to combinations of asphalt with other material, having in mind particularly the development of the Flintkote Co. and the United States Rubber Co.

Do you have any knowledge from your research investigation of any experiments and their results on that type of material?

Mr. MCFADDEN. Yes, sir. We have conducted rather extensive experiments in the use of tar-rubber as a paving material.

Mr. COURTNEY. And what have been the results of those tests?

Mr. MCFADDEN. Well, I think I can sum those up, sir, in just a brief statement. We can design a pavement with tar-rubber as a binder that will be satisfactory for the operation of airplanes in use today equipped with high-pressure tires.

We can design this pavement that will resist the action or the stresses imposed by high-pressure tires.

Tar-rubber is more resistant to the spillage of fuel than asphalt.

Mr. NELSON. Is it as resistant as concrete?

Mr. MCFADDEN. I wouldn't say that it was, sir.

I haven't compared them that way. I don't think it is because we have never found any damage to concrete pavement from fuel spillage.

On the other side of the picture, we have found—and we don't know too much about this because the material has not been in use long enough—but we have found that there is some surface brittleness develops after it has been in use a while. This is further aggravated by the spillage of fuel.

We have no method of simulating or have no accelerated method of determining the durability of pavement, as we have in other forms of investigation, so the only way that we can determine its durability

factor is observation over a period of time where it has been subjected to weather and aging. This pavement has not been in use long enough for us to make that observation over a period of time.

Our only observation is that from the time it has been in on some of our test sections, there is an indication of a developing surface brittleness and checking or cracking.

Mr. NELSON. Do you have sufficient test criteria to give any opinion as to the longevity as between asphalt and concrete?

Mr. MCFADDEN. No, sir. That is what I was trying to develop, sir. We have no method of accelerating this age and weathering effect.

Mr. NELSON. So that the Corps of Engineers considers it has not sufficient test data to give any opinion?

Mr. MCFADDEN. We know that it is more resistant to the spillage of fuel than asphalt. We know that we can design it to carry our present-day load but we don't know the effect of age and weather.

Mr. NELSON. But you can also design an asphalt pavement to help carry present loads: can you not?

Mr. MCFADDEN. Yes, sir.

Mr. COURTNEY. Then is it fair to say that so far as these new materials are concerned, the ones that we have just been speaking of, you are (1) not able to test them for durability and for longevity, and (2) that your tests are therefore at the moment inconclusive on that subject?

Mr. MCFADDEN. I would sum it up by saying this, Mr. Courtney: That we feel the tar-rubber pavement is a reasonable type of pavement to use in the critical areas, subject to the effect of age and weathering, and also to the price competition.

Mr. COURTNEY. And price competition?

Mr. MCFADDEN. That is right.

Mr. COURTNEY. But that you are not able to express a firm opinion on the subject of its life?

Mr. MCFADDEN. It has indications, sir, but we can't forecast the age and weathering effect.

Mr. COURTNEY. Now, Mr. McFadden, we have engineers all around this place today and they are all interested in this subject. If they or any of them have any questions which they would like to suggest we will be glad to answer them.

May I say, to keep these things from degenerating into adversary proceedings, in view of the fact that we are on a quest for information and not for anything else, the committee practice requires that you submit to question. If any of you have any questions which you would like to submit, I am sure the chairman would be glad to entertain them.

Mr. ZACHRISON. I would like to make one statement, Mr. Courtney.

Mr. COURTNEY. Yes, sir.

Mr. ZACHRISON. Mr. McFadden indicated that in the evaluation of competitive bids, asphalt versus concrete, only the pavement itself should be included.

There is another factor that should be considered, however, and that is that we do group many items together for extracting purposes. In other words, we will group together like items which a single contractor should handle, for economic reasons. I would like to make

the point that was raised by Mr. Nelson with respect to including railroads. We would include railroads in a single contract.

Now, we don't like to separate the items for purpose of evaluation only from a contracting standpoint. It was the recommendation of the Corps of Engineers that we include all like items in a contract; in other words, that the evaluation be based on all the construction to be included in a single line item as justified to Congress, whatever it might be, because that was the total amount of money available. But any consideration of price differential should be based on that total; that was purely from a contracting standpoint and not from the standpoint of relative desirability.

Mr. NELSON. I understand the desirability of grouping those things together from the standpoint of contracting but when the Air Force has a 5-percent differential as between types of pavement, the differential should be determined, should it not, by comparing the bids on the pavement?

Mr. ZACHRISON. Then it will require a separate line item for the pavement, in which case you might be paying more money by having separate line items—in other words, subdividing the contract too far.

Mr. NELSON. Well, don't you have line items for pavement?

Mr. ZACHRISON. Normally we don't separate the items, sir, no, sir. We would not have a single item for just the concrete versus asphalt pavement, say. That would be unusual.

Mr. NELSON. In all the justifications I have seen—I may be wrong—there have been line items for all those things.

Mr. ZACHRISON. It includes the grading also.

Colonel ORR. The way that is set up as a line item would be one runway, which would include a railroad if it happened to be in the way and had to be moved. It would be part of the runway. It might include a highway, a railroad, or moving buildings, in the construction of one runway line item.

Mr. ZACHRISON. The point being that in a single contract, we may even group items which are beyond the line items but that we requested the Air Force in this instance for the purpose of evaluation so they would be always on the same basis that whatever differential they decided on it would be based on whatever was included in the justification for that line item and that line item might include whatever is necessary for that runway.

In other words, if it was 4,000 feet of runway, it would include the drainage for that runway, the subgrade, grading, and even the relocation of the railroad.

Mr. COURTNEY. Now, gentlemen, any questions to be submitted for the witness?

Mr. WELLBORN. I would like to ask——

Mr. COURTNEY. Excuse me, Mr. Wellborn; do you have your question written out?

Mr. WELLBORN. No, sir.

Mr. COURTNEY. Will you state it and see whether the Chairman will entertain it?

Mr. WELLBORN. I would like to say: In our schedule of bids, if you do not have separate pavement items included?

Mr. ZACHRISON. I didn't understand the question.

Mr. COURTNEY. Is that a statement or a question, Mr. Wellborn?

Mr. WELLBORN. I am asking if they do not have separate pavement items?

Mr. ZACHRISON. On occasion, they may have separate schedules. You may have a separate bid item within the total bid or scheduled items. Is that what you are asking?

Mr. WELLBORN. Yes.

Mr. ZACHRISON. Yes.

Mr. WELLBORN. What I am trying to get at: When you get your bids in, you can compare the cost between the two types of pavements?

Mr. ZACHRISON. Yes, you can.

Mr. WELLBORN. In other words, you have written this on two schedules, probably, one of all portland cement concrete and one including the portland cement concrete and the flexible pavement?

Mr. COURTNEY. Again, is that a question, Mr. Wellborn?

Mr. WELLBORN. I am asking that, yes.

Mr. COURTNEY. Can you answer the question, Mr. Zachrison?

Mr. ZACHRISON. I can't answer the question in detail. That is a rather complicated question.

Mr. COURTNEY. Well, I think what probably Mr. Wellborn has in mind is that you do ask for unit costs on various items in general.

Mr. ZACHRISON. Yes.

Mr. COURTNEY. When you are inviting bids.

Mr. ZACHRISON. If you amplify that.

Colonel ORR. That normally is the districts. One district will ask for bids on so many cubic yards of sand in the grade, so many cubic yards of rock, so many gallons of asphalt.

Another one will ask for just so many yards of completed pavement. It varies from place to place in different district engineer offices.

Mr. COURTNEY. Out of all these invitations for bids there is an opportunity, whatever method is employed, of comparing either unit?

Colonel ORR. Sure.

Mr. COURTNEY. Or quantities; isn't that correct?

Colonel ORR. It can be compared for pavement only, direct cost for pavement only.

Mr. ZACHRISON. But in the one instance it would have to be based then on the estimated quantities.

Mr. COURTNEY. In one case on estimated quantities, and in the other case on unit; is that right?

Mr. ZACHRISON. You may have a lump sum for the total or in the other case you would have to evaluate it then on the estimated requirements.

Colonel ORR. There are no lump sums for total paving, except the one at Watson, and you abolished that.

Mr. COURTNEY. Any other questions?

Mr. WELLBORN. I would like to pursue this further, if I can.

What I am trying to get at, Mr. Courtney, is that where you have items set up in competition, I can't for the life of me see where there would be any difficulty of letting the contract to the lowest bidder in that particular item. I can't see where it would complicate the contract at all, because usually a contractor will bid an overall job, which might include grading, railroad relocation, lighting of the field, hangers, and everything else. Usually a contractor that large will

sublet a great deal of his contract. If he is principally a grading contractor, he will sublet the pavement or he is principally a pavement contractor he will sublet the grading.

Now, that is just an example. But if the competitive bids between the two types of pavement are set out in your contract as separate items, I can't for the life of me see why it can't be let without any difficulty to the lowest bidder.

Mr. COURTNEY. Well, we have that, then, as an expression of your opinion, Mr. Wellborn.

Mr. WELLBORN. Yes.

Mr. COURTNEY. Mr. McFadden, there has been a question submitted here in reference to the tar rubber, I believe it is called, combination of Flintkote and United States Rubber and some others. The gentleman would like to ask you whether or not the indicated brittleness to which you have referred in your testimony and about which you said you could reach no fixed conclusions because of the lack of time—whether or not that indication was not with reference to the accelerated spillage and traffic tests conducted at Vicksburg?

Mr. MCFADDEN. That was correct.

Mr. COURTNEY. And that is the experiment or the research to which you are referring in making that observation?

Mr. MCFADDEN. That is correct; yes, sir.

Mr. NELSON. Any other questions, gentlemen?

Mr. KUHN. I have a question.

Mr. COURTNEY. All right.

Mr. KUHN. Just to clear the record on this point, Mr. McFadden, there has been testimony relative to the effect of deterioration on both concrete and asphalt pavement where a field is allowed to remain idle for a number of years. Have you conducted any experiments on that phase of this?

Mr. MCFADDEN. We have conducted no experiments on that; no, sir.

Mr. COURTNEY. And observations?

Mr. KUHN. Have you made any observations on that?

Mr. MCFADDEN. I think it is a matter of pretty well common knowledge among the engineering profession, sir, that asphalt pavements will become somewhat dry by not using. They require traffic action to keep them alive. There will be some tendency to become brittle and crack if they are allowed to stand quite a long time free from usage of traffic.

Mr. KUHN. Are there any cases like that?

Mr. MCFADDEN. I think we could find some. I don't know of any right now.

Colonel ORR. That is right.

Mr. COURTNEY. I would like to ask one further question, Mr. McFadden, on this question of different design.

What year or at what time do you consider to be the breaking point between the old design and the present design?

Mr. MCFADDEN. I think we put out our first change in the specification on this current design, about 1950, I think it was. We made revisions and improvements to the specifications since that time at different intervals as they have developed from our specifications.

I could probably check that. Would you like to have the exact date?

Mr. COURTNEY. Yes; if we could have some idea of the breaking point for comparison so far as damage and the like is concerned.

Mr. MCFADDEN. I am sorry, sir, it was before that. The first one we put out, the specification change, for the high-pressure tire, was in July 1947.

Mr. COURTNEY. The question at issue is this:

When would you say that the Corps of Engineers adopted this design so that we may say that from that point on all airfields were constructed to it?

Mr. MCFADDEN. I would say that would be in 1951.

Mr. COURTNEY. About 1951?

Mr. MCFADDEN. Yes, sir.

Mr. COURTNEY. And that design is intended to meet the requirements of jet operation?

Mr. MCFADDEN. Yes, sir.

Mr. NELSON. Mr. McFadden, has the Corps of Engineers made a report recently to the Air Force on your analysis of reported damage to airfields?

Mr. MCFADDEN. Well, we have been making them pretty continuously, sir, for the last several years. I don't remember the date of the last report.

Mr. NELSON. Well, for example, these 21 inspections that you say you have made, were those incorporated in one report or did you report on each instance?

Mr. MCFADDEN. No, sir, they are letter reports that only report on each specific instance.

Mr. NELSON. I suppose it would be quite a job for you to get the committee copies of the reports that you have made?

Mr. MCFADDEN. They could be—the records could be searched and pulled out, sir. It could be done.

Mr. NELSON. I think we ought to have it.

Mr. COURTNEY. Would you like to have it?

Mr. NELSON. Yes.

Mr. COURTNEY. Well, could you at a convenient time get them?

Mr. MCFADDEN. Yes, sir.

Mr. COURTNEY. I take it that these reports are a matter of continuous exchange between the Air Force and the Corps of Engineers, Mr. McFadden?

Mr. MCFADDEN. Yes, sir. They covered quite a period of time.

Mr. COURTNEY. Rather than a composite report on the whole subject?

Mr. MCFADDEN. That is right, and they are formal letter reports.

Mr. COURTNEY. Yes.

Mr. MCFADDEN. We made one investigation about a week or 10 days ago. That report is not in yet. That is the one at Donaldson.

Mr. COURTNEY. At Donaldson?

Mr. MCFADDEN. Donaldson, S. C.

Mr. COURTNEY. I don't think of anything else.

Any other questions that anyone would like to address to the witness?

Mr. ZACHRISON. I would just like to make one point.

Mr. COURTNEY. Yes, sir.

Mr. ZACHRISON. Despite the fact that we got out revised material in 1951 for improvement of the texture and surface of asphalt pavement, that has taken us pretty close to 2 years to develop construction techniques to accomplish that in all areas. In other words, there haven't been comparable practices, I don't believe, in other fields which would enable them to achieve these results immediately. It has taken a little time.

Mr. NELSON. Can they do it now?

Mr. ZACHRISON. We believe they are doing them now. I just wanted to make the point that all the fields accomplished since 1951 have not been necessarily 100 percent, or perhaps never will be.

Mr. COURTNEY. That is because the construction techniques have not kept pace with the new design.

Mr. ZACHRISON. That is correct. We feel they have done that.

Mr. COURTNEY. I don't like these words, but is it true that what you are doing now is facing in this new design?

Mr. ZACHRISON. Well, it has been done, I would say.

Mr. NELSON. It is accomplished.

Colonel ORR. It is being accomplished now.

Mr. COURTNEY. Fine. Good.

Then this question would result from that:

You would say or would you say as a result of your experience and from your investigations, that fields built prior to 1951 would not be expected to respond to the tests put to them by jet operation?

Mr. MCFADDEN. I will say maybe that statement is correct. It might not be expected to. But that doesn't mean that some of them would not.

Mr. COURTNEY. Some of them would not.

Mr. MCFADDEN. Yes, sir. We have always found—I don't think it has ever been brought out—that the older asphalt pavements resist the action of the spillage of fuel more than the newer built pavements. The aging effect on the surface produces some resistance to the infiltration of the fuel.

Now, some of these older pavements built prior to 1950 might have been built to a very dense specification. I wouldn't know. But I would say there is a probability in those fields built prior to that that they might have some difficulty.

Mr. COURTNEY. Will the probabilities increase as the age increases?

Mr. MCFADDEN. The probability decreased with age.

Mr. COURTNEY. I am sorry; decreased.

I think that is all, Mr. Chairman, with Mr. McFadden.

Now, Mr. Duvall, will you give your full name and all of your pedigree for the reporter?

Mr. DUVALL. Belmon Duvall, Chief of the Chemical Thermal Effects Branch, Ohio River Division Laboratories, Corps of Engineers, Cincinnati, Ohio.

Mr. COURTNEY. Your technical training, Mr. Duvall?

Mr. DUVALL. I have been with the Corps of Engineers since 1935, with the growing organization which resolved itself into the Ohio River Division Laboratories, of which the Rigid Pavement Laboratory is a portion.

I have been with the University of Cincinnati. I have been with what is alluded to as the concrete game since 1926, having been with

various cement companies throughout the country, prior to my going with the corps in 1935.

Mr. COURTNEY. Now, has your experimentation been in connection with concrete exclusively, or have you had some opportunity of comparing the flexible-type pavement?

Mr. DUVALL. My investigational work has been, I would say, 95 percent in connection with concrete. There has been a small amount of work accomplished in our laboratories in regard to flexible pavements, in cooperation with the Flexible Pavement Laboratory at Vicksburg.

Naturally, the field investigations which we make have been cases where there are asphalt pavements involved. As a matter of economy, in conducting such surveys, we examine also the asphaltic pavement as well as the rigid pavement at any installation.

Mr. COURTNEY. Well, since cost is really the subject of this inquiry, one of the real subjects of this inquiry, are you able to express an opinion to the committee on your observations of flexible pavement in operation under jet operation?

Mr. DUVALL. On the limited amount of asphaltic pavement that I have inspected, I have never seen any appreciable damage that could be classed as causing failure of the pavement. The damage which I have seen could be corrected very easily as a simple maintenance problem of the air installations unit itself.

Mr. COURTNEY. Now, comparing that with concrete, has there been any damage to concrete that you have observed from either of these two factors, blast and spillage? I take it that is what we are talking about.

Mr. DUVALL. Yes, sir. On concrete, the only damage that I have seen to concrete, of course, is the solvating action of the jet fuels on the joint-filling compounds. In cases of sustained operation, when the jet blast is aimed directly down a joint field with those materials, under sustained operations those materials softened, with the melting point low, and with the blast, a very small amount of that material is blown from the joint.

Mr. COURTNEY. Now, on the subject of material laying on top of the pavement, whether it be asphalt or concrete, what have you to say as to the prevalence of loose material so far as it would affect the operation of a plane, sucking the material into the blades?

Mr. DUVALL. Well, as previously stated by Mr. McFadden, on either type of pavement you have a certain amount of debris. That comes from normal weather conditions. It also comes from the turbulence of operating aircraft, blowing material from the shoulders onto the pavement, and, naturally, you would have a small amount of that on any pavement, regardless of whether it is a rigid or a flexible pavement.

Now, I know, or I have heard statements in regard to damage caused by those materials at various installations around the country. Those have not been stated by the engineering officers concerned as to whether they occurred on a flexible pavement or a rigid pavement.

I have examined one compressor blade that they claimed was damaged by loose material on a pavement picked up the——

Mr. COURTNEY. But the source of the material would not identify it?

Mr. DUVALL. That is right.

Mr. COURTNEY. So that the presence of debris is not necessarily a result of the type of pavement. It can come from other sources?

Mr. DUVALL. Correct, sir.

Mr. COURTNEY. And frequently does?

Mr. DUVALL. Correct.

Mr. COURTNEY. Now, could you give the subcommittee some idea of how extensive your observations have been of these different types of pavement, having in mind the particular subject to which we are addressing ourselves?

Mr. DUVALL. A rough estimate, I would say, during the past 4 years: I have inspected on an average of 12 to 15 fields per year.

Mr. COURTNEY. Per year?

Mr. DUVALL. Yes, sir.

Mr. COURTNEY. And from that, you have arrived at the opinion which you have just expressed?

Mr. DUVALL. Right, sir.

Mr. COURTNEY. On the occasions where you have made inspections, has it been because of report of damage or requirements of repair?

Mr. DUVALL. In some instances it has been reported damage. In the major portion of the inspections that I have made, it has been for the purpose of accumulating information for long-range planning and for investigations which we propose to conduct.

The developments in the aircraft industry are changing so much that to accept the fact that you have a certain type of aircraft, for example, designated as an F–86 or an F–84, and the damage was caused by that particular aircraft or certain characteristics have been noted with that aircraft; that information is often misleading, unless you know specifically what type of engine was in that aircraft, and unless you know the operational characteristics at that particular field, because the operations at one field are one thing and you go to another group of men at another field and they are entirely different. So you have to investigate——

Mr. COURTNEY. That has to do with housekeeping and discipline.

Mr. DUVALL. Right. So simply a reported damage to a pavement can't be accepted for a bald statement. You must investigate the circumstances.

Mr. COURTNEY. Then you found no uniformity as to cause when you examined—that is what you are trying to say, isn't it?

Mr. DUVALL. That is correct.

Mr. COURTNEY. As to cause for any of the damages or repairs to which your attention was directed.

Mr. DUVALL. That is right.

Mr. COURTNEY. Mr. McFadden has testified that he had some 21 reports, from a rather quick count, of damage. How does that correspond with your recollection as to the number of places which you might have examined in the period of your investigations?

Mr. DUVALL. Of course, our laboratory not being all-inclusive of the airfields branch, I couldn't make an accurate statement as to what percentage of the 21 Mr. McFadden stated. I would say at possibly 6 or 8 installations I have seen minor damage.

Mr. COURTNEY. We were just trying to get some picture of the extent of your investigations.

Mr. DUVALL. Yes. At almost any base which you may visit you will find some minor surface erosions.

Mr. COURTNEY. Are you speaking of asphalt or concrete?

Mr. DUVALL. Asphalt.

Mr. COURTNEY. Asphalt.

Mr. DUVALL. And you will find some minor damage to joint seals on the rigid pavements. It all depends on how an individual evaluates damage. Some of them get overly excited if they have just a minor impingement pattern on the pavement. Actually, I would say in 95 or perhaps greater percentage of the cases the pavements are entirely structurally sound. They are serving their intended purposes. They are not a hazard to the aircraft. They are unsightly, perhaps.

Mr. COURTNEY. Are you familiar with the experiments conducted at Port Hueneme?

Mr. DUVALL. I have visited the Port Hueneme on three occasions and have discussed their investigations with various individuals at that installation.

Mr. COURTNEY. And have you seen the slabs or panels, or whatever they are called, out there?

Mr. DUVALL. I have, sir.

Mr. COURTNEY. Out there and in operation?

Mr. DUVALL. Yes, sir.

Mr. COURTNEY. And in expressing your opinion you are including the information which you have accumulated from that source, among others?

Mr. DUVALL. That is only partial. You see, we also are conducting a somewhat similar investigation.

Mr. COURTNEY. And that is the one at Vicksburg?

Mr. DUVALL. No. That is the one at the Rigid Pavement Laboratory at Cincinnati.

Mr. COURTNEY. I beg your pardon. But there is also an experiment at Vicksburg, is there not?

Mr. DUVALL. That is right, sir.

Mr. NELSON. Mr. Duvall, you made a report recently on the results of your experiment?

Mr. DUVALL. The most recent full-coverage report is the one which was given at Port Hueneme, at the Navy Symposium.

Mr. COURTNEY. Just to break in, that is the symposium of April 17 and 18?

Mr. DUVALL. That is right, sir.

I might point out, Mr. Courtney, in connection with this instance, that our laboratory is concerned more with the long-range planning. Of course, we must evaluate the effects of current operation. I am primarily interested in the effects of rockets on pavements, of afterburners on pavements, the developments in the aircraft propulsion units, as to how those might affect pavements.

Mr. COURTNEY. And that, of course, would focus your attention on material found on the surface of any pavement, wouldn't it?

Mr. DUVALL. That is right.

Mr. NELSON. When the surface of concrete crumbles away, is that what you call spalling?

Mr. DUVALL. That is one type that you can call spalling, yes.

Mr. NELSON. What causes that?

Mr. DUVALL. I can only give you my personal opinion.

Mr. NELSON. Does anyone know?

Mr. DUVALL. I can only give you my personal opinion. There are perhaps 100 answers for that, perhaps more, depending on the indi-

vidual you are questioning. It might be due to poor construction practices. It might be due to poor materials. It might be due to the type of traffic or the particular conditions of subjection to the pavement during its life. Without a specific example and having investigated that pavement, to find the cause of spalling would be a pretty difficult one.

Mr. NELSON. Does it occur quite often in concrete fields?

Mr. DUVALL. Not under well-constructed pavements. The materials are known and the quality of materials you are using are carefully controlled.

Mr. NELSON. Is there any possibility that it might be caused by heat and blast?

Mr. DUVALL. It can be caused by heat and blast.

Mr. NELSON. Well, have you had sufficient experimental data to know whether or not the jet blast from jet aircraft would accelerate that process?

Mr. DUVALL. The current operational aircraft—that is a limited group—to the best of our knowledge, and on the basis of our tests at Eglin Air Force Base, do not generate sufficient heat on the surface of the pavements to cause spalling.

Now, if we go into the rocket phase, subjection of pavements to rockets, that is another story entirely. If we go into afterburners, that is another story.

Mr. NELSON. Well, is there a possibility that continual subjection of the concrete pavement to the heat from the jet aircraft might over a period of years cause spalling?

Mr. DUVALL. It is entirely possible.

Mr. NELSON. But you don't have enough experimental data to reach any valid conclusions?

Mr. DUVALL. Right. Nor during the years with which we have had jet aircraft operating on concrete pavements have we seen any damage to concrete pavements due to jet operations.

Mr. NELSON. When you get spalling in a concrete runway, what is the cure for it?

Mr. DUVALL. Usually replacing the slab concerned where spalling is occurring.

Mr. NELSON. Replacing the slab?

Mr. DUVALL. Yes.

Mr. NELSON. So you take the old slab out and put a new one in?

Mr. DUVALL. That could be done. In many instances it is more economical, if the spalling is widespread, to overlay that perhaps with asphaltic concrete. It is a matter of economics there.

Mr. NELSON. In other words, that is cheaper than to replace the slab?

Mr. DUVALL. Much cheaper than to replace the slab. If the slab is structurally unsound, then it is another story.

Mr. COURTNEY. Now, do any of you gentlemen have any questions, in the audience, that you would like to address to Mr. Duvall?

Mr. WELLBORN. I would like to ask a question, if I may.

I am Mr. Wellborn, again.

Mr. Duvall, in the blast effects of jets on the joint sealer in concrete, do you have any method of estimating the cost of repairing those joints in comparison with the areas which have been reported damaged on asphaltic concrete pavements?

Mr. DUVALL. That is a question that would have to be answered by Air Force installations group, Mr. Wellborn. I personally have never gone into the maintenance costs of joint sealing compounds on concrete pavements.

Mr. WELLBORN. Do you have any figures on the cost of—I mean cost figures on the amount it costs to fill the joints in concrete, per linear foot, for instance?

Mr. DUVALL. No; I do not, sir. That information, I believe is on record.

Mr. WELLBORN. Well, I know through experience that to fill joints and to repair them is quite an expensive item.

Mr. COURTNEY. Well, now, Mr. Wellborn, these are for questions now, and they are not for statements.

Mr. WELLBORN. I am sorry, sir.

Mr. DUVALL. Mr. Courtney, I believe Mr. Wellborn's statement will need a great deal of amplification before it can be answered properly for the record without being misleading.

Mr. Wellborn did not define what he meant by a joint—depth, width, and so forth.

Mr. COURTNEY. Well, that is another subject and it is beyond your field of research.

Mr. DUVALL. Right, sir. But I would like to make that point.

Mr. COURTNEY. Are there any other questions that anyone would like to submit to the witness?

Mr. TAUBER. A question of Mr. McFadden.

Mr. COURTNEY. All right, Mr. McFadden. Will you read it, then?

Mr. TAUBER. Will Mr. McFadden explain the full nature of the indicated brittleness on tar-rubber pavement surfaces and does he feel it is more than just a surface condition, rather than one extending through the material? I am referring to these tests he spoke of.

Mr. MCFADDEN. At the moment, based on our observations of the test pavements at Vicksburg, which is the only one we have to base an opinion on, it is a surface checking. The cracks do not extend through the pavement, or even through the surface, of course. But there is some indication of cracking and brittleness on the surface.

Mr. TAUBER. Mr. McFadden, wasn't that the result of the pavement condition after 1,500 cycles of accelerated load tests, so-called?

Mr. MCFADDEN. No, not entirely. The report we have from the laboratory indicates that this condition has taken place on pavements that have not been subjected to spillage and it has been aggravated by the application of fuel to the surface.

Mr. TAUBER. I see.

I have another question, if I may.

Mr. COURTNEY. All right.

Mr. TAUBER. Is it not true that tar-rubber pavements have been put down for many years and have been giving excellent service; that is, tar pavements I am speaking of, just plain tar pavements?

Mr. MCFADDEN. You are speaking now of tar-rubber?

Mr. TAUBER. Tar.

Mr. MCFADDEN. Tar has been used as a paving material. It isn't as widespread as asphalt, but has been used for several years.

Mr. TAUBER. No. I am speaking for many years. Let's say for a period of 20 years or more.

Mr. MCFADDEN. I expect it has been used for at least 20 years.

Mr. TAUBER. Yes. Do you believe the addition of certain synthetic rubbers to suitable pavement tars would be advantageous?

Mr. MCFADDEN. Our experimentation indicates that the addition of synthetic rubbers reduces its susceptibility to temperature change.

Mr. TAUBER. Mr. McFadden, are you familiar with the tar-rubber pavement at Friendship Airport, in Baltimore?

Mr. MCFADDEN. No, not at all.

Mr. NELSON. Mr. Duvall, this isn't a very comprehensive report we have from you in this symposium.

Mr. DUVALL. What is that, sir?

Mr. NELSON. The report of this symposium, or whatever it was, on airfield pavements for jet aircraft, out in California. Have you ever made a report on the results of your experiments insofar as they concern filler in concrete pavements?

Mr. DUVALL. That work is accomplished by the flexible pavement laboratory on joint filling compounds, sir.

Mr. NELSON. It is.

Mr. DUVALL. Not by our laboratory .

Mr. NELSON. Your experiments have been confined almost entirely to concrete?

Mr. DUVALL. To concrete materials.

Mr. NELSON. And especially their reaction to JATO assist?

Mr. DUVALL. Right.

Mr. NELSON. That is all I have.

Mr. COURTNEY. The information you have gathered, then, is for comparative purposes?

Mr. DUVALL. For comparative purpose, for long-range planning.

Mr. COURTNEY. Now, let's see. Colonel.

Colonel ORR. My name is Herman Orr. I am a colonel in the United States Army Corps of Engineers.

Mr. COURTNEY. Now, Colonel, your particular job at the moment is what?

Colonel ORR. I am on special assignment for the Chief of Engineers on construction inspection and investigation of anything that he might assign me to.

Mr. COURTNEY. And how long have you had that duty?

Colonel ORR. Well, I have been out of college 32 years, 24 years with the highway departments in building of pavements of all kinds, and 8 years with the Army.

Mr. COURTNEY. Eight years with the Army.

Colonel ORR. Airfields and Army camps and other things.

Mr. COURTNEY. Well, the subject of this inquiry, as you know, is asphalt and concrete.

Colonel ORR. Yes.

Mr. COURTNEY. And with particular reference to damage from blast and from fuel spillage. What opportunity have you had to observe the airfields that have been built?

Colonel ORR. Well, my primary duty is with new construction, to see that it is done according to the Chief of Engineers' specifications, plans, and policies.

I have been to many of the construction jobs and have visited some that were completed, investigated some of the so-called failures or damages, though that was merely an incident to my construction duties.

Mr. COURTNEY. Well, in that connection has there come to you any knowledge or are you able to form an opinion as a result of your experience on the amount of damage which occurs by reason—if it does occur—of the new type jet operation on asphaltic fields?

Colonel ORR. Well, I have observed that at several places, those that were reported as being damaged, and I have never seen any damage of any consequence that would in any way interfere with the usage of the field.

Mr. COURTNEY. In other words, instances of alleged damage have been reported to you by your superiors for you to investigate?

Colonel ORR. Well, in 1 or 2 instances, yes. Others—I just did it by accident as I was going by on some other duty.

Mr. COURTNEY. As part of your general——

Colonel ORR. Just to improve my own knowledge.

Limestone Air Force Base was one, and Otis was one, and the famous Williams. I investigated that one, too.

Mr. COURTNEY. Well, Williams has been spoken of here. Let's get that up on the table and on its way. What is the situation at Williams?

Colonel ORR. I came back on active duty with the Army in July of 1952, and I heard soon afterward about Williams. So I went down to see what it was. At that time the pavement was perfect, because the commanding officer said it wasn't any good and he wouldn't use it. So it had no damage whatever on it, though it was reported completely destroyed.

I went to some of the representatives of the district engineer who built it, and they informed me that it had not been given a proper density, that it hadn't been rolled enough when it was hot to consolidate the pavement mixture, so it would probably absorb jet fuel more than a normal pavement would, though at the time I was there it had never been subjected to any use of any kind.

I was back there some time in the fall of 1953, I have forgotten exactly the date, and it was being used for visiting aircraft only. When occasionally a visitor came in, he was allowed to park on this new apron. There was no damage at that time that would in any way interfere with the usage, and no repairs had been done on it. I don't know what it is now.

Mr. COURTNEY. Then, because of that construction failure or fault, you would not consider any evidence furnished by the use of that pavement to have any influence—that should have any influence on your considerations?

Colonel ORR. I think that should be completely ignored, for two reasons: One, it wasn't built according to our standard practice and the other one is, it has never been used enough to prove whether it is good or bad. We would expect that it would be damaged more than our standard pavements.

Mr. NELSON. Then, when anybody complains about the job at Williams Air Force Base, they are complaining about the way it was built, not the way it operates, because they have never operated it?

Colonel ORR. That was at the time, the last time I was on it. They did pour some jet fuel out of a Coca-Cola bottle and dig a hole in the pavement with a screwdriver and take a picture of it and say it was no good.

I saw the picture over in the Pentagon.

Mr. NELSON. You have inspected Limestone?

Colonel ORR. Yes.

Mr. NELSON. And you found no damage there?

Colonel ORR. Well, the reports were that the pavement was a failure. I happened to get there on the day there was no flying, so I was allowed to go all over the pavement in detail. I would imagine there were 500,000 square yards in use. The only damage at that time was 4 places about the size of ashtrays where 4 planes had parked and fuel had dripped one night. The commanding officer had told me that he had asked for $25,000 to repair the field, because it was bad pavement. And when I told him he could do it for 50 cents, he asked me how I found that out. And I told him I had spent about 25 years repairing pavement and I knew it was a minor operation. So he said he didn't know, he was a flyer. But there is no damage at Limestone, up to November when I was there last, November 1953, that would be consequential.

Mr. NELSON. For the record, Limestone is all asphalt pavement?

Colonel ORR. It is 100 percent; yes.

Now there were some places on the runway ends where planes, jets, they said, had turned on the afterburner too quick, and let it burn before they started rolling, and it had scorched the surface. I think there were 4 or 5 places there that had just made a blast spot on the surface. It hadn't gone into it. Of course if it stayed there very long, it would have burned a hole through it.

Mr. NELSON. You inspected Otis Field, too?

Colonel ORR. I was at Otis, in, I think, September of 1952. They had repaired a lot of pavement there that was built in World War II. I don't know what the cause of the damage was. We had a report that there had been some extensive repairs, but it was old pavement that had been—I don't know how old it was, but they had resurfaced a considerable area. I don't know what caused the damage.

Mr. NELSON. What was the construction there?

Colonel ORR. It was asphalt.

Mr. NELSON. You don't know what the damage was, because it had all been resurfaced before you got there.

Colonel ORR. That area that was bad had been resurfaced by the air installation officer before I was there.

Mr. NELSON. Have you inspected any other fields?

Colonel ORR. Well, Craig Field, at Selma, Alabama. I was there recently. They have a refueling and maintenance apron. That is a training field, where they use the T–33, I believe they call it, the training plane. They are servicing those planes on an apron that was built in 1941, before we had a specification or a plan or anything else. It was a crash, rush job. They used the highway department specification for the pavement. The pavement is identical with the roads in that area. It is more seriously damaged than any pavement I have seen anywhere. It is still being used.

Mr. NELSON. T–33 is a jet?

Colonel ORR. Yes. They have some peculiarity. I don't know much about them. But it seems they spill more fuel than some of the other types.

Mr. NELSON. Have you ever inspected Clovis Air Base?

Colonel ORR. No.

Mr. NELSON. Are you familiar at all with that field? When was it built?

Colonel ORR. Which one was that?

Mr. NELSON. Clovis Air Force Base.

Colonel ORR. I don't know, sir. I haven't been——

Mr. NELSON. I think it is in New Mexico, but I wouldn't know.

Colonel ORR. It is there. I normally don't get to a place except those that are under construction, whether they be concrete or asphalt. We try to see that they are properly built. I have no responsibility for maintenance.

Mr. NELSON. Your function is to examine new airfields?

Colonel ORR. Well, I am supposed to see that the field is properly built and, if not, report to the Chief and let him take action that is necessary.

Mr. NELSON. And in the course of that duty, you also examine damage which may be caused.

Colonel ORR. If there is any reported while I am there, I always look at it.

Mr. NELSON. Have you found any major damage to any field built out of asphalt?

Colonel ORR. No, sir; with that exception at Selma, which is, of course, an exceptional case because of the type of pavement it was and the use. It has been used 13 years and it cost 50 cents a square yard. So we shouldn't complain much on it.

Mr. NELSON. What happened at that field?

Colonel ORR. The constant fuel spillage from these T–33 planes has completely dissolved the pavement.

Mr. NELSON. That is the one you described. That is all right. That is all I have.

Mr. COURTNEY. Colonel, have you examined the installation at Thule?

Colonel ORR. No; I have never been there.

Mr. COURTNEY. Nor Keflovik?

Colonel ORR. Yes; I have been there several times.

Mr. NELSON. That is an all-asphalt field.

Colonel ORR. It is all asphalt.

Mr. COURTNEY. Have you observed any damage at that field?

Colonel ORR. No. That field hasn't—well, I guess they do have a few jet planes there, I don't know, but it is chiefly a transport plane, with the propeller-type engine.

Mr. COURTNEY. Do you know about the Azores?

Colonel ORR. Yes; I have been there several times.

Mr. COURTNEY. Have you seen any jet damage there?

Colonel ORR. I haven't observed any, no. There are very few jet planes there. I think they use that for stopping point, as they cross, but not a constant operation.

Mr. COURTNEY. Have you observed Hickam?

Colonel ORR. I haven't been to Hickam. I want to go there this winter, but I haven't had a chance yet.

Mr. COURTNEY. They send you there in July.

Mr. NELSON. Colonel, who is in charge of maintenance and repair at these Air Force bases?

Colonel ORR. They have an air installation officer at each field who is directly responsible. He works under major commands I believe.

I am not sure of that. I know that is how it was operated during the war, because I did it. But the Air Force can furnish that. I don't know how it is done.

Mr. NELSON. You don't know whether or not they are qualified engineers?

Colonel ORR. Well, I found some air installation officers who were highly qualified. Some are not, just like all the rest of us.

Mr. NELSON. When you examined the installation at Limestone and found out the commanding officer was asking $5,000 to do a 50-cent job, who went around with you and inspected that?

Colonel ORR. I was with one of our engineers, but after I finished my trip I went to see the colonel, commanding officer, and reported to him on what I had seen.

Mr. NELSON. You didn't talk with any engineer on the base?

Colonel ORR. No, sir.

Mr. NELSON. Or any air installations officers?

Colonel ORR. No. I have talked to the present air installations officer who is there now.

Mr. NELSON. Is he an engineer?

Colonel ORR. Yes, I think so.

Mr. NELSON. Does he know all about pavements?

Colonel ORR. No. I think you expect the impossible if you expect any engineer to know all about everything.

Mr. NELSON. Let's change the question. Does he know anything about pavements?

Colonel ORR. I should think he would know something, yes; I didn't quiz him exactly on it. He is doing, I thought, a respectable job. I just happened to be thrown with him one afternoon in a joint inspection of some facilities. I didn't have a chance to go into his qualifications in detail.

Mr. NELSON. That is all I have, Mr. Courtney.

Mr. COURTNEY. Colonel, now what about the use of concrete? What damage have you observed on it? From jet operations?

Colonel ORR. I don't think that jet fuel would damage the concrete or the blast, normal blast from a jetplane would ever get hot enough to damage it. It would damage the sealing compound used in the joints. But I have never seen any indication where the damage was enough to make any difference. It will blow the top of it out, but it always leaves enough in there to hold the seal a reasonable time.

Mr. COURTNEY. And what about fuel spillage?

Colonel ORR. Well, that would dissolve the joint sealing compounds.

Mr. COURTNEY. Beyond that, you would find no damage?

Colonel ORR. I don't think—certainly up until now it hasn't. It might have some effect on it during aging. I don't know what that would be in 20 years. But I have seen no indication of it.

Mr. COURTNEY. Now, what about this question of material on the surface of fields, from whatever source derived, which might interfere with the operation of aircraft?

Colonel ORR. Well, the joints on concrete pavement will spall. The pavement slabs crack and turn loose small particles of concrete, and the asphalt pavement also deteriorates and releases some particles of aggregate.

I have seen at least the airfields where they are sweeping the runways, either type. So there must be something on each of them. I have seen them sweeping concrete runways and asphalt runways.

Mr. COURTNEY. Well, in your observations on these various fields, haven't you seen debris or material accumulated from sources other than the pavement?

Colonel ORR. Well, generally the edges of the runways have a gravel or some granular compound to use in emergency. If a plane runs off they don't want it to run off in the mud, so they surface it, and some of that material very often gets on it. I think that is the dirt or granular material from the sides of the pavement, chiefly, on there.

Mr. COURTNEY. Shoulders are usually of loose aggregate, are they not?

Colonel ORR. Yes.

Around the ends of the runway they put a light pavement to keep it from blowing away from the blast of the planes. But along the side of the runway, they don't.

Mr. COURTNEY. I think that is all, Colonel.

Thank you Colonel, very much.

Any questions that any of the panel would like to ask of the colonel?

Mr. SEIBEL. Mr. Courtney.

Mr. COURTNEY. Yes, sir.

Mr. SEIBEL. I believe Colonel Orr said he made an inspection of Otis Air Force Base. I have been up there twice within the last 4 months. I am wondering if the colonel is referring to the asphaltic apron at the alert hangars?

Colonel ORR. No. That was under construction when I was there. The damage that I saw, and it was reported before I went there, was the old apron that is on the side of the field next to the gate. You cross it as you go in.

Mr. SEIBEL. Yes, sir; I know where that is.

Colonel ORR. The other one was under construction. I haven't seen it since I visited it.

Mr. SEIBEL. I have personally observed severe damage to the apron and I was wondering if that is what you had in mind.

Colonel ORR. No; I didn't see it.

Mr. SEIBEL. Thank you.

Mr. COURTNEY. Any other questions, Mr. Chairman?

(No response.)

Mr. COURTNEY. Mr. Chairman, I think that is all from the Corps of Engineers, with the supplemental data from Mr. McFadden.

Now we have the results of the experiments at Port Hueneme to be put in the record, Mr. Chairman.

I am not just sure at what time we can put it in the record, but certainly before Friday, when we expect to close. Hueneme is a great distance from here, as you know.

We intend, also, Mr. Chairman, to put in the symposium to which reference has been made as a part of the exhibits in the record.

If you gentlemen can for the assistance of the committee suggest any other scientific data or technical information or source material which would be of value in a study of this problem for the committee and for all concerned, we would appreciate having that information from you.

Mr. ZACHRISON. I would like to verify first: The two items which I believe you want are first a list of the Air Force bases built since the advent of jet aircraft which have had failures, and the other listing was of those reports of the 21 installations?

Mr. COURTNEY. Twenty-one damage reports; yes.

Mr. ZACHRISON. Which we have gotten from the Air Force.

Mr. NELSON. I want a copy of your report made to the Air Force.

Mr. ZACHRISON. Right.

Mr. MCFADDEN. You wanted, out of this 21, how many built prior to the advent of the jet?

Mr. COURTNEY. I think if you would just distinguish between those which were prior to the present criteria or present design.

Mr. MCFADDEN. That is right.

Mr. COURTNEY. So we may evaluate them in the light of your testimony.

Mr. ZACHRISON. There would be one point I would like to make there, and that is we definitely don't get reports of all failures of all pavements. We primarily are concerned with the pavements only up to the time we turn them over. We would only have knowledge of such failures as occurred by reason of such trips as Colonel Orr or Mr. McFadden made, bases where we might observe it or where the Air Force called our attention to it. I don't want to imply that we have knowledge of all the failures that might have occurred.

Mr. NELSON. I also would like to make this clear for the record. You are being paid money by the Air Force in order to make diligent research into the effect of jet blast and jet fuel spillage on pavements.

Mr. ZACHRISON. Yes.

Mr. NELSON. So in natural pursuit of that purpose you should receive all complaints as to deleterious effects on pavements?

Mr. ZACHRISON. We would expect to.

Colonel ORR. There is one thing there I think that would help the entire problem and that is, if we could get that coordination between the maintenance and usage and construction, we could improve, I think, the entire situation, if we can get those.

Mr. NELSON. I think that is a good point, Colonel.

I want to thank the representatives from the Corps of Engineers very much for coming up here and taking of their time to give us what I consider very fair and impartial information, well supported by the facts.

Mr. ZACHRISON. Thank you.

Colonel ORR. There is one thing there that I am not sure how it will sound in the record. One correction: The AIO, air installations officer, at Limestone may not be the same one now as the one that was there the first trip I made. I don't know who was there the first time. I don't remember this other gentleman's name.

Mr. NELSON. Thank you, Colonel.

Mr. COURTNEY. Mr. Chairman, then may we recess for an indefinite period? And if the interested parties will let us have addresses to which telegrams can be sent or telephone calls made, when the Hueneme people will come we will undertake to notify them in sufficient time to get here. I think everybody is pretty close to the city. Certainly they are closer than Port Hueneme.

I think we have everybody's address. We have the Concrete Institute in Chicago and the Asphalt Institute in New York, Flintkote, and United States Rubber in New York.

Mr. SEIBEL. That is correct.

Mr. COURTNEY. That, Mr. Chairman, should be relatively a short interval.

Before we adjourn, Mr. Chairman, I should like to have interpolated in the record the symposium to which reference has been made.

REPORT ON SYMPOSIUM ON AIRFIELD PAVEMENTS FOR JET AIRCRAFT, HELD AT PORT HUENEME, CALIF., APRIL 17 AND 18, 1952

By John M. Griffith, Engineer of Research

The United States Naval Civil Engineering Research and Evaluation Laboratory sponsored a symposium on the effects on airfield pavements of jet aircraft. Attendance at the meeting was approximately 450, consisting principally of military and civilian engineers of governmental agencies and engineers connected with the several industries who supply paving materials. A number of representatives of asphalt producers were included among the latter group.

PROGRAM OF THE MEETING

Thursday a. m., presiding, F. E. Lowance, technical director, United States Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme, Calif.

10 a. m.: Welcome, Cmdr. F. C. Tyrrell, CEC, United States Navy, officer in charge, United States Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme, Calif.

10:10 a. m.: Definition of problem, Comdr. J. C. Luppens, CEC, United States Navy Shore Establishments Division, Bureau of Aeronautics, United States Navy, Washington, D. C.

Discussion.

11 a. m.: Air Force requirements, Lt. Col. Gayle L. Smith, Air Research and Development Command, United States Air Force, Baltimore, Md.

Presiding: D. E. Parsons, Chief, Building Technology Divisions, National Bureau of Standards, Washington, D. C.

1:30 p. m.: Investigational program of United States Army, C. R. Foster, Chief, Flexible Pavement Branch, Waterways Experiment Station, Corps of Engineers, United States Army, Vicksburg, Miss., and B. U. Duvall, Ohio River Division Laboratories, Corps of Engineers, United States Army, Cincinnati, Ohio.

Discussion.

2:30 p. m.: Airfield pavements, Directorate General of Works, the Air Ministery, London, England.

Discussion.

3:40 p. m.: Early planning and exploratory tests, L. A. Palmer, Head, Soil Mechanics and Paving Section, Bureau of Yards and Docks, United States Navy, Washington, D. C.

DINNER

Presiding: Capt. J. R. Perry, CEC, United States Navy, commanding officer, United States Naval Construction Battalion Center, Port Hueneme, Calif.

Speaker: Dr. L. N. Ridenour, vice president, engineering, International Telemeter Corp., Los Angeles, Calif.

Friday a. m., presiding, Gayle McFadden, Chief, Airfields Branch, Office of the Chief of Engineers, United States Army, Washington, D. C.

9 a. m.: NAVCERELAB's program, J. A. Bishop, Director, Soils and Pavements Division, United States Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme, Calif.

Discussion.

9:50 a. m.: Trends in aircraft design, Fred A. Payne, office of the chief engineer, North American Aviation, Inc., Los Angeles, Calif.

Discussion.

10:45 a. m.: Modernizing existing airfield pavements, panel discussion.

1. S. Wallace (representing Col. J. A. Barrett, USAF, Air Force installations representative, San Francisco, Calif.)

2. C. R. Foster, Chief, Flexible Pavement Branch, Waterways Experiment Station, Corps of Engineers, United States Army, Vicksburg, Miss.

3. F. M. Mellinger, Director, Ohio River Division Laboratories, Corps of Engineers, United States Army, Cincinnati, Ohio.

4. Lt. F. N. Finn, CEC, United States Navy, Public Works Office, 11th Naval District, San Diego, Calif.

5. Henry Aaron, CAA Office of Airports, Paving and Soils Branch, Washington, D. C.

LUNCH

Friday p. m., presiding, Harmer E. Davis, Director, Institute of Transportation and Traffic Engineering, University of California, Berkeley, Calif.

1:30 p. m.: Concrete design, A. A. Anderson, manager, highways and municipal bureau, Portland Cement Association, Chicago, Ill.

2 p. m.: Bituminous design, J. M. Griffith, engineer of research, the Asphalt Institute, New York, N. Y.

Discussion.

3 p. m.: Summary of papers, J. M. Simpson, Head, Structures Research Department, United States Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme, Calif.

3:30 p. m.: Demonstration of NAVCERELAB test; procedure at testing area, Port Hueneme, Calif.

ADVISORY COMMITTEE FOR THE SYMPOSIUM

J. R. Berry, USAF.
J. A. Bishop, NAVCERELAB.
H. T. Davis, University of California.
P. A. Hahn, CAA.
C. W. McCormick, California Institute of Technology.
G. McFadden, Corps of Engineers, United States Army.
F. L. Meara, USAF.
L. A. Palmer, BUDOCKS.

SUMMARY OF PAPERS

Comdr. J. C. Luppens presented a considerable amount of test data on temperatures and blast velocities experienced with current jet planes in use by the Navy. These data were presented in great detail in graphical and tabular form and will be generally available when proceedings of the symposium are published.

As a typical example, Commander Luppens cited pavement level temperatures for one Navy plane as being approximately 300° F., with turbine at idle speed, 370° F., with turbine at full military power, and 700° F. with the after burner in operation. He noted that normal operations involved a runup to full military power of about 10 seconds at the end of the runway.

This time factor, however, may occasionally be greater. Commander Luppens stated that fuel spillage with Navy planes was insignificant and therefore posed no problem at Navy airfields.

Another interesting point in Commander Luppens' paper concerned pavement impact stresses caused by planes when landing. He noted that strain gages, attached to landing gear, indicated that impact stresses were sometimes more than twice the dead load on the landing gear. The initial reaction to such information might lead one to believe that landing areas would have to be designed for twice the normal wheel load; however, discussion brought out the fact that pavement failures normally occurred first in areas of slowly moving or standing loads, and that landing areas usually were the last to fail. It is probable that pavements are capable of standing a considerable degree of overloading when of extremely short duration, and when the load is applied in the manner as with landing planes.

Lt. Col. Gayle L. Smith's paper covered temperature and blast velocity data for Air Force planes, similar to that discussed by Commander Luppens for Navy planes. Colonel Smith pointed out that temperature and blast characteristics

of both Navy and Air Force planes were quite similar in degree. He noted that assist takeoff units, which are now coming more into the picture, spill acid fuels which disintegrate portland cement concrete and that it was not likely that all such spillage could be completely eliminated.

He stated further, that jet fuel spillage was a problem only in service areas and could be minimized by good housekeeping. In summary, Colonel Smith stated that the Air Force needed structurally sound pavements for gross plane loads of 400,000 pounds (the B-36 loading is about 190,000 pounds on each dual-tandem assembly), tire pressures 200 pounds per square inch, jet exhaust heats of 350° to 450° F., and exhaust velocity of 300 feet per second.

In the discussion which followed, Mr. R. K. Compton, a civilian engineer of the Fifth Naval District, indicated that the asphaltic pavement performance in his district has been quite satisfactory. He introduced several photographic slides illustrating the minor nature of jet plane effects on the asphaltic pavements in this particular area.

The paper of Mr. C. R. Foster summarized the results of special pavement tests at Eglin Field, Fla. Mr. Foster noted that time-motion studies had been made on several current models of Air Force planes. Special pavement panels containing thermocouples were constructed at Eglin Field and jet-blast impingement tests were made with the various planes operating over these panels according to their usual procedures. Pavement surface temperatures in these tests seldom exceeded 250° F. and minor erosion began under normal operating procedures only when the pavement surface temperature reached about 300° F.

Mr. B. U. Duvall then discussed future operations of planes incorporating assist takeoff units, such as JATO (jet assist takeoff) and RATO (rocket assist takeoff). He described a special test unit which has been set up at the Ohio River Division Laboratories in Cincinnati, and noted that pavement level temperatures approaching 2,000° F. might be experienced when such units were mounted close to the pavement surface. He noted that thermal shock of such high temperatures affected various aggregates in portland cement concrete to various degrees, and presented a tabulation listing the order in which various types of aggregates withstood thermal shock.

Group Captain Faville of the British Joint Services Mission stated that fuel spillage on asphaltic pavements was a definite problem in England, and he was pleased to note that comments by previous speakers had indicated that it was not a particularly serious problem in this country. England is experimenting with a number of products applied in thin overlays, prefabricated sheetings, and resinous paints, as a means of alleviating fuel spillage problems.

Captain Faville also stressed that good housekeeping would go a long way in solving their fuel spillage problems. He stated that they also were experiencing a moderate amount of damage due to jet blasts on both asphalt and portland cement concrete pavements; the latter damage being confined to the joint sealing materials.

Mr. L. A. Palmer described the early Navy tests with jet planes on pavement surfaces and introduced a number of photographs portraying damage which had been experienced in both asphaltic and portland cement concrete pavements at various airfields. Damage to portland cement concrete pavements was confined mainly to joint sealing materials, while damage to asphalt pavements consisted of eroded areas caused by heat and blast of jet turbine exhausts.

He cited measured surface temperatures with the F7U plane of 516° F., and emphasized that the Mav7 definitely had problems on their airfield pavements. He then described current Navy practice of requiring concrete pavements in certain areas, but implied that this was not an entirely satisfactory solution.

Mr. J. A. Bishop then described the current investigational program of the Navy Research and Evaluation Laboratory at Port Hueneme. They have a jet turbine mounted in a movable frame and have constructed pavements of asphaltic concrete, portland cement concrete, brick, and several special surfacings. These pavements will be tested with the jet turbine mounted at various heights above the several pavements, and at varying angles of inclination to the pavement.

Perhaps one of the most enlightening papers given at the symposium was by Mr. Fred A. Payne, of North American Aviation, Inc., followed by a discussion by a representative of the Boeing Aircraft Co. It was nated that they were continually under pressure to improve speed, range, and load-carrying characteristics of military aircraft. It is their contention that developments are now available to provide improved air performance, but that runways are a limiting factor.

Improved afterburner designs are available but they will make for much higher heat and velocity conditions. Takeoff and landing speeds also would be increased, and this in turn will require either longer runways, or else assist takeoff units and auxiliary drag brakes (parachute).

Mr. Payne stated further that we might expect future temperatures at the turbine exhaust orifice of 3,500°–5,000° F., velocities of 2,000 feet per second, maximum angle of inclination of about 20°, and minimum height of exhaust orifice above pavement of about 12 inches. He did not give figures for pavement level temperatures and velosities but implied that they would be much higher than at present.

It is contended that fighter planes must be designed with a minimum of landing gear, thus requiring that the body of the plane be close to the ground. Certain aerodynamic requirements and limitations on length of runway also make it now necessary for them to have fairly high angles of inclination of the jet turbine with the horizontal. (Present angles vary from 5° to 15°, and future angles may be as high as 20°.)

In summary, it would appear that special surfacings must be developed for use in limited areas in order to provide pavement characteristics demanded by the aircraft designer for planes of the future.

The panel discussion by Messrs. Wallace, Foster, Mellinger, Aaron, and Lieutenant Finn discussed conditions at specific locations and what had been accomplished to date in attempting to provide pavements for future aircraft. Mr. Mellinger described the rehabilitation and extension of Lockbourne Air Force Base where they had made use of both asphalt concrete and portland cement concrete. In areas where severe heat and blast conditions were expected, a slag aggregate was used in the portland cement concrete and sawed joints were used.

Mr. Aaron cited instances where authorities at civilian fields at first were quite disturbed when military agencies first requested permission to use asphaltic pavements at their fields for jet planes. They were quite concerned as to the anticipated damage, based on the rumors which were prevalent. Mr. Aaron stated, however, that since operations had actually been initated at these fields, the operating officials were no longer concerned because the actual damage had been negligible.

Mr. A. A. Anderson of the Portland Cement Association presented a paper in which he pointed out that damage had not occurred to the portland cement concrete, but only to the joint filling materials. Apparently, they have not yet an entirely satisfactory solution to the joint problem and at present they recommend a slight underfilling of the joint. He recognized that certain aggregates would make their pavements more susceptible to damage by higher heat and velocity conditions and offered to make the facilities of his organization available to provide the best possible portland cement concrete pavements to meet future requirements.

Your Engineer of Research presented a paper in which it was recognized that some damage had occurred to asphalt pavements, both due to fuel spillage and to heat and blast effects. It was emphasized, however, that the extent of this damage had sometimes been greatly exaggerated. It was pointed out that fuel damage occurred only in permeable pavements and there was confined principally to portions of the apron where mechanical servicing and testing were accomplished and occasionally on the ends of runways.

We pointed out that fuel spillage was a considerable fire hazard, as well as a potential source of damage to the pavement, and recommended that an impermeable asphalt surface and a reduction of fuel spillage by good-housekeeping measures would go a long way in solving the fuel-spillage problem. It is noted further that smooth-surfaced asphalt pavements would provide best resistance to blast damage, but that possibly special surfaces, such as brick, or other heat-resisting material, would be required in limited areas to resist extremely high heat and blast conditions imposed by certain current and future planes. We expressed the desire of the Asphalt Institute to cooperate to the fullest possible extent in a solution of present and future airfield problems.

The symposium served a beneficial purpose by assembling those most interested in the problem for a free and open discussion. All papers and discussions presented will be published in the near future and will furnish specific and valuable data for those of us who are intimately concerned with this problem. Copy of our paper attached herewith.

Asphaltic Pavements for Jet Operational Airfields—Paper Presented Before the Meeting Held by the United States Navy at Port Hueneme, Calif., April 17, 18, 1952

(By John M. Griffith, engineer of research, the Asphalt Institute)

Military aircraft designers have made rapid advances in Navy and Air Force planes since the beginning of World War II. The gross loads of these aircraft have increased many times over prewar planes, speed and range have been increased considerably, means of propulsion have undergone considerable change, and other technological improvements have advanced current planes appreciably beyond those of prewar days.

During this period of rapid aircraft advancement our airfield pavement-design procedures and criteria likewise have been in a state of change. It has been necessary to extrapolate, verify, and adjust our designs in order to meet the requirements both for the ever-increasing load characteristics and types of landing gear of these changing aircraft. It has been necessary also to formulate some new concepts on pavement requirements, particularly with respect to jet-propelled planes.

The rapid increase in gross load and landing-gear changes led to the first big change in the design of airfield pavements. At the beginning of World War II the B–17, and shortly afterward the B–24, were classed as very heavy bombers. These planes had a maximum wheel load of approximately 30,000 pounds which was carried on single tires inflated to slightly less than 100 pounds per square inch. Even such a wheel load was then well beyond existing design experience which had been confined almost solely to pavements for the commercial DC–3. During the same period the gross loading of naval aircraft was also increasing at a rapid rate. It was, therefore, necessary for the paving specialist to accelerate the tempo of his developments and, in a short time, to provide design procedures and criteria by which to construct adequate pavements for these heavy aircraft. Intensive studies were made, basic design procedures were selected, and special studies were conducted to provide valid design criteria.

Within a relatively short period of time the B–29 was introduced, and the load of this plane was approximately twice that of the B–17 and the B–24. The 60,000-pound assembly load of the B–29 was carried on dual wheels, using the same tires and inflation pressures as the B–17 and B–24.

It was, therefore, necessary to determine the effects of dual wheel loading and 60,000-pound gross loads on pavement structures and to provide adequate design criteria for these planes. It was considered by many that surely the B–29 was the ultimate in the superbomber, but not many years had elapsed before the B–36 was unveiled to the public. This plane had a gross load of about three times that of the B–29, and originally the load on each landing gear was to be carried on a single wheel of 114-inch diameter.

Studies indicated that pavement requirements for these tremendous loads would be reduced materially if multiple-wheel assemblies were used to carry the loadings. These planes now have main landing gear composed of dual-tandem, sometimes called twin-tandem, wheels. Needless to say, design criteria had to be further modified in order to provide satisfactory pavements for these planes. One sometimes wonders if the B–36 is the ultimate in size and gross load, or if even larger planes are to follow when more efficient powerplants are developed. Colonel Smith, in a previous paper, indicated the probability that we have about reached the maximum on size and loads of military aircraft.

While developing design procedures and criteria for heavier and heavier planes, and for planes of different wheel-loading characteristics, a number of misleading ideas were encountered. Some engineers considered that impact stresses imposed in a pavement by a plane when landing were perhaps many times the stresses under standing planes. Commander Luppens pointed out in a previous paper today that impact loadings are seldom more than about twice as great as standing loads. Some also believed that stresses under standing planes with motors running were much greater than stresses beneath planes with their motors dead, due to vibratory effects. Scientifically conducted tests and observations have modified or disproven these and other misconceptions.

Pavement stresses under standing loads are nearly the same, regardless of whether or not the motors are running. Stresses under landing planes, although the impact load may be greater, are actually less severe on the pavements than standing or slowly moving loads, perhaps due to the short duration

of the impact load. As a result of such studies, the various problems encountered from great increases in gross load and changes in type of landing gear have been solved in a satisfactory manner, and adequate load-design procedures are now available for all existing aircraft.

The development of aircraft propulsion units is similarly in a rapid state of development at the present time. From the beginning of aviation history until recent years the conventional piston-type motor furnished the sole means of propulsion. In the past few years, however, there has been very rapid development and change in types and characteristics of propulsion units. We are now familiar with such units as the turbojet, turboprop, ram-jet, rocket, jet-assist takeoff (JATO) rocket takeoff (RATO), and lately there are indications that we may someday look forward to atomic-powered planes. Our present concern, however, is to provide pavements which are suitable for current jetplanes and for conditions which are now known or foreseeable in the near future.

It is generally recognized that the present jetplanes have two characteristics which may lead to damage of asphalt pavements. One is jet-fuel spillage, and the other is effect of heat and blast.

Engineers of the Asphalt Institute have inspected and reported on most of the military airfields surfaced with asphalt-type pavements which have been subjected to any appreciable amount of traffic by jet aircraft. They have reviewed the behavior of asphalt pavements at these airfields with the engineering officials who are intimately familiar with their behavior. The consensus of opinion following such inspections and discussions is that primary concern at Navy airfields is relative to the heat and blast effects, with fuel spillage appearing to be a relatively minor problem. This is perhaps due to the fact that many of the Navy planes must operate from aircraft carriers where fuel spillage constitutes a severe fire hazard.

On the other hand, fuel spillage appears to be somewhat more of a problem at Air Force airfields. It would appear, however, that it also is the consensus of opinion that the areas where potential damage is likely to occur are limited in extent, and that the actual damage to asphalt pavements which has occurred to date has also been quite limited.

Let's examine existing conditions, then, so as to evaluate the problem in a rational manner. First, one might ask, "Where are the areas of potential damage from heat and blast effects?" Observations to date have indicated that eroded areas in asphalt pavements are principally found on those areas of the aprons where mechanical testing is performed and sometimes near the end of the runways.

Second, the question might be asked, "Where are the areas of potential damage from fuel spillage?" One of the earlier model jet aircraft spilled fuel promiscuously from its fuel tank overflow device while taxiing over all areas traversed. This deficiency, however, has been almost completely corrected in later model planes and the current planes do not normally spill fuel while taxiing. Present observations indicate that fuel spillage occurs predominately in refueling areas where fuel tanks are sometimes filled to overflowing.

Next, we should inquire as to the nature of the damage. Erosion of asphaltic pavements due to heat and blast effects take a form elliptical in shape and the pattern is from 3 to 5 feet in width and 10 to 20 feet in length. Erosion patterns which have been observed are seldom greater than three-fourths inch in depth and are usually less than one-half inch. A typical example of what is sometimes called severe erosion is illustrated in figure 1, and often is removal of a seal coat rather than injury to main portion of pavement. Here it may be seen that some of the fine aggregate has been eroded away, leaving a coarse textured surface. The integrity of the pavement surface is little affected by such erosion and may if desired be patched readily with a small quantity of sand mix.

It has been observed that rough-textured asphalt pavements may be somewhat more susceptible to heat and blast damage than smooth-textured pavements. This difference is perhaps accounted for by increased turbulence resulting from the impingement of the blast on the rough surfaces. The theory has been advanced that incomplete combustion of the fuel in the jet turbine results in fine particles of burning jet fuel becoming lodged on the protruding aggregate and intensifying the heat applied to the pavement, but this would appear doubtful.

Observations have indicated that the ordinary asphalt seal coat with coarse stone cover is not normally satisfactory where blasts of high temperature and velocity from jet turbines are encountered. It has been noted also that jet plane exhausts may remove the seal coat while the asphalt pavement beneath remains

intact. An illustration of this occurrence may be seen in figure 2. Here, the seal coat was removed in a typical elliptical pattern but the asphaltic concrete pavement beneath was unaffected.

Damage to asphalt pavements by fuel spillage occurs only when the fuel is absorbed into the pavement. Facetiously, it has been said that "screwdriver damage" caused by someone curious to see just how much of the weakened pavement can be removed has been more noticeable than actual disintegration under spillage. It is a fact that many asphalt pavements did satisfactorily withstand considerable fuel spillage, even in the early days of jet aircraft when fuel spillage was more prevalent than it is now.

It is to be noted especially that there is a great difference in the rate at which asphalt pavements absorb fuel within a given period of time, depending upon relative porosity and the frequency and quantity of fuel spillage. This difference is related to design of the mix, particularly in respect to density.

One illustration of a taxiway pavement which has successfully withstood heavy fuel spillage is shown in figure 3. This pavement had a dense and smooth textured surface which did not absorb the jet fuel. Performance of this pavement was considered to be entirely satisfactory.

Another illustration of an asphalt pavement satisfactorily withstanding considerable fuel spillage is shown in figure 4. This area is a service and refueling apron. In contrast, however, figure 5 illustrates the effects of fuel spillage on a cold-mix asphaltic pavement made from sand available at the site and cutback asphalt. This pavement was quite permeable and absorbed jet fuel readily.

In view of these differences in behavior, it therefore may be appropriate at this time to summarize inspection reports on some of the major Navy airfields which will indicate the nature and extent of damage to asphalt pavements by jet aircraft as it appears to us.

San Diego NAS.—Facilities at this site comprise approximately 1 million square yards of asphalt pavement. There is little or no damage from blast of fuel spillage, except that some erosion from jet blasts has occurred on a limited section of the runway where jet planes begin their takeoff.

El Toro MCAS.—A considerable area of the pavements at this airfield are now being strengthened by asphalt overlays. There was no evidence of fuel damage on any of the existing asphaltic areas. There were, however, several areas where some blast erosion was evident.

Whiting NAS.—Taxiways are of asphalt concrete and aprons are partially of asphalt concrete. Some blast damage and a small amount of fuel damage was noted at the joint between the two types of pavement and blast erosion was noted in the few areas of the asphalt pavement. Maximum depth of erosion was approximately one-half inch.

Alameda NAS.—Special tests were conducted on asphalt pavements at this installation with the F9F being held in one position and operated at full throttle. Severe erosion occurred in the asphalt pavement. It was later learned, however, that these pavements were of the cold-mix type.

Grumann Airfield, Long Island.—This airfield is not a regular Navy field, however, it is located at the Grumann factory which produces the Navy F9F jetplane. Observations indicate no detrimental effect from either fuel spillage or blast.

Cherry Point MCAS.—No fuel-spillage damage and only moderate blast damage was reported on the asphalt pavements at this field which has an extremely heavy operational program.

Jacksonville NAS.—Report dated December 1950 states that runways and taxiways are of asphalt concrete. At the time there was no damage due to fuel spillage. Blast damage did not occur until a seal coat had been placed over old asphalt pavements; then the seal coat was eroded away in a few areas.

It is recognized that conditions at some of the airfields cited above may have changed somewhat since the inspections and reports were made. Most of the reports, however, are of recent origin and reflect recent conditions.

A review of inspection reports on Air Force fields indicate that some damage has occurred to asphalt pavements at some of their airfields. Damage at Air Force fields is attributable more to fuel spillage than to heat and blast damage as at Navy fields.

We therefore recognize that some damage has been experienced on asphalt pavements as a result of jet-plane traffic, however, it is considered that such damage is sometimes magnified to an unwarranted degree. A flield survey consisting of measured areas would doubtless reveal that only a fractional part of

1 percent of the total area of asphalt pavements on jet-operational airfields had been damaged by the combined effects of blast and fuel spillage.

Be that as it may, let's examine the circumstances surrounding the damage which has occurred and determine what may be required by way of improvement. First, there is the item of heat and blast damage. Facts at our disposal may be summarized as follows:

(*a*) Heat and blast damage by current jet planes usually results only from mechanical repair operations or preflight checks, then with only certain of the current jet aircraft.

(*b*) Areas of potential damage are limited to parts of the service apron and ends of runways.

(*c*) Observations indicate the smooth-textured asphalt pavements are generally more resistant to heat and blast effects than rough-textured pavements.

(*d*) Asphalt seal coats are less resistant to heat and blast damage than smooth-textured asphalt pavements.

(*e*) It is recognized that there is a upper limit to heat and blast resistant properties of asphalt pavements.

(*f*) Each jet plane has specific heat and blast characteristics, depending upon the height of the exhaust orifice above the pavement surface, angle of inclination of the jet turbine, specific type of jet turbine, and whether or not an afterburner is used.

(*g*) The heat and blast effects of a specific plane upon an asphalt pavement are dependent upon the duration of dead-stand operations and to a minor extent on prevailing air temperature and wind direction and velocity.

(*h*) Probable heat and blast effects of future jet aircraft are largely speculative at the present time. Minor modifications in the landing gear and in turbine alinement may completely alter heat and blast characteristics at pavement level of both current and future planes.

Consideration of the above factors indicates that improved performance in asphalt pavements may be gained both by improvements and modifications in pavement design and modifications in aircraft design. Efforts should be made to provide dense, smooth-textured surfaces which will reduce turbulence to a minimum and thereby better reflect the heat and blast effects. Asphalt overlays of approximately an inch in thickness will resist heat and blast effects better than seal coats and should be used where surface improvements are required.

A special surfacing such as brick or other heat-resisting material might be used in limited areas which are susceptible to severe heat and blast effects. Mr. Mellinger, in his paper, stressed the fact that such areas are quite limited in extent.

Simultaneous efforts should be made to insure that the aircraft designers give due consideration to heat and blast effects as related to the economics of airfield-pavement construction, particularly in view of circumstances which may be imposed under combat conditions, where rapid reconstruction may be required. This would seem particularly desirable in view of presently indicated trends of increasing heat and blast effects as JATO and RATO units are installed.

It is understood that some consideration has been given to placing jet turbines in a horizontal position, thus largely minimizing or eliminating heat and blast effects on pavement surfaces. Certainly this would be an appropriate modification from the viewpoint of the paving engineer, and it would appear that such a modification would also be desirable for Navy carrier operations.

The second potential source of damage to asphalt pavements, of perhaps more concern to the Air Force than to the Navy, is the spillage of jet fuels. It has previously been noted that smooth-textured impermeable asphalt surfaces are highly resistant to jet fuel damage, as penetration of the fuel into the pavement is required to injure such pavements. It is, therefore, necessary that asphalt pavement surfaces be made impermeable, particularly in areas of potential fuel spillage, if they are to adequately resist fuel damage. This may be accomplished by proper engineering design and control.

A further desirable aid in solving the fuel-spillage problem may be possible through corrective maintenance operations and refueling procedures, and even perhaps by further improvements in turbine design. Negligible fuel spillage in carrier operations indicates that such a goal is obtainable. It should be noted that widespread spillage of jet fuels constitutes a serious fire hazard. Present congested conditions at many airfields often require that planes be parked closely together and a fire in one area might quickly spread to adjacent planes if there is much free fuel on the pavement.

From the foregoing it becomes apparent that to obtain maximum resistance to heat, blast, and jet-fuel effects smooth-textured and impermeable surfaces are required. These characteristics may be secured in the following manner:

(*a*) Factors affecting permeability and surface texture must be appraised by design and construction personnel, and pavements thereafter constructed which will provide these characteristics.

(*b*) Coarse aggregates must be properly graded with sufficient fine aggregate, mineral filler, and asphalt cement added to fill the voids to such extent as will insure an impervious surface having smooth texture, together with a satisfactory workability in construction operations.

(*c*) Plant mixing and laying operations must be such as to eliminate aggregate segregation in the completed pavement.

(*d*) Rolling operations must provide maximum pavement density or, conversely, minimum pavement voids. All mixtures have an optimum rolling temperature at which compaction is most effective. In general, rolling should follow closely after laying, when the asphalt binder is in a fluid condition. Occasionally, however, mixes are encountered which displace under immediate rolling. In such case rolling must be delayed or the mixing and laying temperatures reduced.

(*e*) Air voids of 5 percent or less are required for an impermeable pavement.

Asphalt pavements generally increase in density when subjected to heavy traffic in warm weather. Field tests have indicated that densification increases with increasing tire pressure and pavement heat. Rolling of the surface with rubber-tired equipment will often reduce the void content in inadequately compacted pavements. Thus, on new pavements it is suggested that rolling with rubber-tired equipment be included in construction procedures to insure maximum pavement impermeability. Such rolling should be applied shortly after finishing with steel-wheel rollers and while the pavement still retains some of its initial heat. Experimental work is required to determine optimum rolling conditions for rubber-tired equipment, but pavement temperatures should probably be in the range of 120° F. to 150° F., tire pressures in the range of 100 to 150 p. s. i., and maximum wheel loads used which will not cause pavement displacement. Usually only a few coverages will be required to produce a satisfactory degree of impermeability.

Where existing pavements are sufficiently permeable as to absorb jet fuel, there are at least two procedures for remedying such conditions. The first and most certain remedy is by the addition of a properly designed overlay pavement. Such overlays should be placed to a depth of three-fourths inch to 1 inch, contain well-graded aggregates of about three-eights inch maximum size and a minimum of 5 percent of mineral filler. Optimum asphalt content should be determined by current Navy and Corps of Engineers criteria for 100 p. s. i. tire-pressure mixes, and which in such thin sections will have adequate shear resistance for even higher unit loads.

An alternate method may be employed if laboratory tests indicate that proper mix proportions were used but where construction compaction has been inadequate. In locations where weather conditions provide reasonably high-pavement temperatures (above 100° F.) rubber-tired rolling with the type of equipment previously mentioned may produce a satisfactory degree of impermeability. Where suitable rolling temperatures cannot normally be obtained, surface heater may be used to supply additional heat to the pavement. Such heating operations have a tendency to flush a small quantity of asphalt cement to the surface and perhaps a light coat of limestone dust immediately following the heating operations and just preceding rubber-tired rolling will assit in achieving the desired surface impermeability.

CONCLUSION

The thoughts expressed in this paper may be summarized briefly as follows:

(*a*) The past decade has witnessed tremendous advances in military aircraft. Satisfactory solutions of problems encountered in greatly increased loadings and changes in types of landing gear have been accomplished through adequate programs of research and development by military agencies.

(*b*) Asphalt pavements generally have withstood in a satisfactory manner the heat and blast effects of most of the current military aircraft when operated in a conventional manner. Deadstand operations of a few current planes has caused some surface erosion in certain limited areas.

(*c*) Smooth-textured asphalt pavements are more resistant to heat and blast effects than rough-textured pavements or seal coats.

(*d*) Smooth-textured, impermeable asphalt pavements are required to resist penetration of the jet fuels and damage to the pavement. Air void contents of less than 5 percent are recommended to provide the desired degree of impermeability.

(*e*) Asphalt pavements can be constructed which will provide adequate resistance to damage by fuel spillage and which will also provide reasonable resistance to heat and blast effects of most of the current planes. Extremely severe heat and blast conditions will require special sufacings in certain areas.

(*f*) Thin asphaltic overlays and, under certain conditions, rubber-t'red rolling may be necessary to provide adequate resistance to fuel spillage in existing pavements which are permeable.

(*g*) Rubber-tired rolling of new pavements while still warm will undoubtedly provide a greater degree of impermeability.

Finally, it would appear that every attempt must be made to provide a realistic and economical solution to the problems posed by jet aircraft. Pavement facilities must often be strengthened and expanded rapidly during emergency periods, and it is frequently necessary to build and repair bomb damage under combat conditions and in a minimum of time. Adequate research and development work as well as a cooperative approach by all concerned will be required to furnish reasonable and adequate solutions to our current and future airfield problems. The Asphalt Institute will be happy to cooperate and participate in such work to the maximum possible extent.

Mr. NELSON. The committee will now adjourn, subject to call of the Chair.

(Whereupon, at 11:50 a. m., Monday, February 8, 1954, the committee adjourned, subject to call of the Chair.)

(At the conclusion of the testimony the following was exchanged between the subcommittee and the Department of the Air Force:)

MARCH 3, 1954.

Mr. JOHN M. FERRY,
Special Assistant to the Secretary of the Air Force,
The Pentagon, Washington D. C.

DEAR MR. FERRY: In the testimony which you presented to the subcommittee on February 4, 1954, you referred to a directive of the Air Force dated January 8, 1954, establishing bidding criteria with a 5-percent differential in favor of concrete. You explained that the figure 5 percent had been arrived at after some deliberation and that it was, in your opinion, as far as the Air Force felt justified in going.

As the testimony concluded the subcommittee was left with the very definite impression that 5 percent was the fixed differential.

The subcommittee now learns that the Corps of Engineers' office at Little Rock, Ark., revised an invitation for bid dated January 29, 1954 for the construction of an airfield, IFB #ENG–03–050–54–24, by addendum No. 3 which papers are dated February 12, 1954, fixing the differential at 10 percent instead of 5 percent.

I am directed by the chairman to ascertain why this information was not given to the subcommittee during the hearings. The subcommittee desires to know:

1. When the criteria of January 29, 1954, was changed?
2. Who authorized the change?
3. Whether a new addendum later than that of January 8, 1954, has been issued?

This information must be in our hands before the record can be closed and a report of the subcommittee issued. The subcommittee is dismayed that this action, which must have been in the process during the course of the testimony by the Air Force representatives, was not brought to its attention at that time.

By direction of the chairman,

JOHN J. COURTNEY, *Special Counsel.*

DEPARTMENT OF THE AIR FORCE,
OFFICE OF THE SECRETARY,
Washington, March 12, 1954.

Hon. WILLIAM E. HESS,
Chairman, Subcommittee on Defense Activities, Committee on Armed Services, House of Representatives.

DEAR MR. CHAIRMAN: I refer to Mr. Courtney's letter of March 3, expressing your concern that your subcommittee was not apprised of the fact that the bidding procedure being applied to the paving project at Little Rock Air Force Base is contrary to the criteria published by the Air Force on January 8, 1954.

The indicated inconsistency between current Air Force criteria permitting the payment of a 5-percent premium for concrete pavement and the 10-percent premium permitted in the case of the Little Rock invitation for bids, results from the fact that instructions to advertise on the basis of a 10-percent premium at Little Rock were issued prior to release of current criteria.

"The decision to use the 10-percent differential at Little Rock was made on December 22, 1953, at which time the 10-percent figure had been tentatively established by the Air Staff." This percentage was subsequently revised and the criteria, as issued formally on January 8, 1954, specified a 5-percent differential. "The district engineer issued invitations to bids on January 29, 1954, and without the knowledge or consent of the Air Force used the January 8, 1954, directive with the 5 percent spread in lieu of the previously directed 10 percent." When it was discovered that the original directive had not been used, then addendum No. 3 was issued in order to comply with the originally directed 10 percent.

"The fact that your subcommittee was not advised of the action taken in the case of Little Rock Air Force Base can be attributed only to the fact that questioning (sic) did not prompt recollection of the action already taken in this single instance." No award of contract has been made to date and, accordingly, the Corps of Engineers has been requested to issue an addendum to the bidding documents specifying a 5-percent differential.

I wish to assure the committee that it was not our intention to deviate in the slightest degree from the Air Force testimony and that we desire to cooperate to the fullest extent at all times.

Sincerely yours,

JOHN M. FERRY,
Special Assistant for Installations.

APPENDIX

Comments on Exhibit A of Asphalt Institute Presentation

1. *Abilene.*—Work is currently underway on the asphalt-concrete combination. Mr. Gray has been answered by formal letter on this project.

2. *Edwards.*—No alternate was taken on this job. Because of the experimentation and flight testing conducted at this base, an all-concrete runway was specified. In spite of absence of competition the price was very low.

3. *McClellan.*—Alternate bids taken here indicate a wide spread but the decision to take the higher concrete bid was based upon functional use of this apron. It is a maintenance apron in front of a recently completed maintenance hangar at McClellan.

4. *Kinross.*—In this case the asphalt alternate was accepted.

5. *Brookley.*—This job involves apron, and since it is a maintenance apron concrete only was invited.

6. *Limestone.*—This job has not been awarded as yet. Award scheduled for April 1954.

7. *McGhee-Tyson.*—This case is 1 of the 5 and which has been fully explained.

8. *Donaldson.*—In this case the asphalt alternate was accepted.

9. *Brookley.*—This is apron. Alternates were invited and concrete was accepted.

10. *Forbes.*—Alternate bids for this pavement strengthening were taken and award was made on asphalt alternate. After award was made OCE published a new criteria to be followed in strengthening airfield pavements based upon pavement evaluation of existing pavements. This policy was issued in July 1952 and stated where existing concrete pavement is less than 55 percent of full design that a concrete overlay or flexible pavement would be used, whichever is more economical. If existing concrete pavement is 55 percent of full design or greater, a flexible overlay is satisfactory. This policy covered all jobs under design, out for bid and under contract. As a result of application of this policy, OCE recommended that the Forbes job be changed to concrete overlay. Air Force concurred in this recommendation on August 15.

11. *Lincoln.*—Because of small differential (3 percent) in cost of this job, the concrete alternate was taken.

12. *Altus.*—In this case the asphalt alternate was taken.

13. *Smoky Hill.*—This case is 1 of the 5 which has been fully explained.

14. *Carswell.*—In this case the entire 3,000 feet of extension was taken in concrete because the existing runway is concrete. It was not desirable to construct an extension of 3,000 feet with 2,000 feet in asphalt and 1,000 feet in concrete. The taxiway extension, however, was constructed in asphalt since this extension joined an old existing asphalt runway which was converted to a taxiway.

15. *Hunter.*—Asphalt was taken here with the exception of a small section on the end of the runway which was done in experimental tar-rubber sections for spillage and blast tests which were conducted later.

16. *MacDill.*—In this case asphalt was taken

17. *Pinecastle.*—The 393,000 square yards of apron is in asphalt and is the one General Ramey commented on as giving trouble in his presentation. Remainder of new pavements at Pinecastle are concrete.

18. *Donaldson.*—This job was constructed in concrete. On the total cost of the job the percentage is small. Note Asphalt Institute alleged "savings" of $303,000 involving 302,000 square yards of pavement, only $1 per square yard.

19. *Homestead.*—This job is not under contract. Concrete will not be used except possibly for hangar access. The entire job is being designed for asphalt with upper 1½ inch of wearing surface in critical areas to be of tar-rubber.

20. *Sewart.*—First portion of pavement in 1951 was done in asphalt. The 1953 portion is constructed of concrete.

21. *Canton-Akron.*—No record of this. It is either a CAA or National Guard job.

22. *Camp Campbell.*—This job was canceled.

23. *Wold-Chamberlain.*—Cost differential very small. Concrete was taken. All pavements at this municipal airport are concrete.

24. *Westover.*—This job comes under August 1952 policy and is combination asphalt and concrete. Additional work is coming up later and will come under January 8 policy. If 5 percent or less, it could go all concrete, but will probably follow previous policy as exception, since a portion of the field is presently under construction.

25. *Portsmouth.*—This is 1 of the 5 which has been fully explained.

26. *Schenectady County.*—No record of this. It is either a CAA or National Guard job.

27. *Plattsburg.*—This is 1 of the 5 which has been fully explained.

The following statements are made in regard to certain testimony furnished by Mr. Gayle McFadden, from the Office, Chief of Engineers:

Reference to pages 348–351: Mr. McFadden stated that to his knowledge there were no changes in the type of aircraft or its operation or the amount of spillage by reason of any refinements (since January 1952).

Certain types of jet aircraft are constantly being improved. These improvements, or modifications, have generally been limited to engines, weapons and other vital equipment. As aircraft weights are increased more powerful engines are required which develop higher exhaust temperatures and greater blast velocities.

Many new types of jet aircraft are in the development stage and ground operating characteristics are not fully known. For example, the new B–66, the replacement for the old B–45, is in production. It is heavier and faster than the B–45 which was used in the tests at Eglin Air Force Base. A new fighter, now in production, is expected to be more critical than any in general use so far. Data as to fuel spillage, heat, and blast which was furnished by the manufacturer of this new fighter, are described as follows:

Spillage: (*a*) 5.5 gallons for each of 7 starts and 12 power reductions from after burner use to idle power. This is normal operation in checking the afterburner; (*b*) 1 to 3 quarts for each start, 1 to 4 quarts for each stop.

Blast temperature: (*a*) Air temperature of 700° F. at the pavement surface 40 feet from the tail pipe; (*b*) air temperature of 912° at the pavement surface 30 feet from the tail pipe as the aircraft reaches a speed of 5 miles per hour at the beginning of the takeoff with the engine at full power.

So far as is known the above example is typical of developments in other fighter types. More powerful engines are being developed for the B–47 and B–52. Ground operating characteristics other than loading are unknown, but it can be expected, without a doubt, that heat and blast effects will be considerably greater. In view of these developments and the knowledge that new jet aircraft now under test and development will be still more critical, concrete pavement is the best known type that will insure long life under ground operational conditions now and in the future.

Reference to pages 353, 354 and 357: Exception is taken to the statement that a charred and eroded area caused by blast could be cured by a treatment of asphalt and a cover coat of mineral aggregate. Exception is based on the following reasons:

(*a*) Seal coats (asphaltic surface treatments) are entirely unsatisfactory where jet aircraft are operating. Seal coats are quickly eroded by blast and are extremely susceptible to dissolution by jet fuel.

(*b*) A seal coat merely covers a blemish and adds nothing structurally to the pavement.

(*c*) The cover coat of mineral aggregate becomes an additional source of potential damage to jet engines.

For the reasons cited the Air Force has directed that seal coats not be applied to new, dense graded, hot plant mix asphaltic concrete.

As to methods of repairing areas damaged by jet fuel, Mr. McFadden recommends a similar surface treatment. This type of treatment will not restore the pavement to its original state. In cases where the asphaltic binder in the original pavement has been heavily diluted a satisfactory repair can only be made by replacing the damaged pavement with new material equal to that of the

original pavement. Anything other than that constitutes a temporary and expedient repair.

The methods of repair suggested by Mr. McFadden are acceptable for correcting deficiencies developing in ordinary cases, but the Air Force cannot accept these methods as a cure-all in areas where jet aircraft ground operations are constant. Only under the rarest of circumstances would maintenance personnel at an Air Force base be able to make repairs which would be comparable to the original pavement, for the reason that asphaltic equipment, technical know-how and laboratory testing equipment are just not available. Furthermore, commercial asphaltic plants are not usually equipped to furnish small quantities of the high type material required, except at an exorbitant price. In most cases commercial plants refuse to make plant changes necessary to produce relatively small quantities of the required mix. The end result is that the base air installation officer is required to continue temporary patching until such time as a major overall repair project can be undertaken by contract. In the meantime the operational areas become a hodgepodge of temporary repairs which further aggravates the maintenance and operational problems because they lack resistance to the effects of jet fuel, heat and blast.

To date, the Air Force acknowledges the fact that instances of damage have been small as compared to the total area of pavement. We acknowledge our responsibility to maintain these pavements to highest efficiency with the limited means and funds available, but it is not difficult to visualize the extra man effort required to supply buckets, water, mops, and brooms for housekeeping in addition to that to make repairs particularly during emergency conditions.

Reference to pages 359–360: To clarify the record as to the purpose of blast pads the following facts are presented.

Blast pads have only one function; that is, to alleviate or prevent soil erosion on turfed or unturfed areas by jet blast. After considerable study of the problem as to the extent of protection required, methods to be employed, and cost, it was decided that blast pads are required in the overruns at runway ends, on shoulders of warmup pads and on sharp turns in taxiways. It is at these locations where jet blast is directed off the pavement causing severe erosion of the soil.

In order to provide a relatively inexpensive type of surface treatment, without reference to load bearing requirements, yet capable of providing some degree of resistance to blast, it was determined that the pads should be constructed of a 2-inch thick asphalt pavement of the same quality as used in the top wearing surface of asphalt airfield pavement. Normally, this surface is placed directly on the existing soil without special treatment of the soil provided the soil type is such that a satisfactory bond can be obtained for the asphalt surface.

Mr. McFadden's statement that these pads are composed of 6 inches of base and 2 inches of concrete is in error. However, it presumed he had in mind shoulder pavement which is now specified at B–47 and B–52 bases, except that the top 2 inches of surface is of asphalt.

The requirement for paved shoulders at B–47 and B–52 bases arises for two reasons, namely, protection of shoulders from blast of outboard engines, and the occasional load imposed by the outrigger gear which extends, in the case of the B–52, beyond the pavement edge. However, paved shoulders are prescribed for only taxiway and apron shoulders.

Very few blast pads have been constructed to date and therefore, the effectiveness of this type of erosion protection is not known. It is expected that maintenance of blast pads will be substantially less than that which would be required if the pads were not provided.

Paved shoulders, as described above, have not yet been constructed since the requirement has just recently been established.

Reference to pages 60 and 368: Mr. Gray of the Asphalt Institute stated that critical areas could be confined to approximately 10 percent of the total area. Mr. McFadden stated the critical areas would be the area around fueling points and the maintenance apron.

These gentlemen are apparently not aware of the faot that any area where an aircraft is parked is potentially a maintenance or fueling area. Every aircraft not undergoing hangar maintenance is constantly being attended to when on the ground. The Air Force attempted to limit the critical areas to those generally recommended by OCE, but due to the fact that some degree of maintenance is accomplished at every parking location; parking patterns change for every type of aircraft; base commanders do not always use the same parking

pattern; and changes in base missions result in changes in parking, fueling, and maintenance requirements, the Air Force decided that for complete flexibility the entire apron area must be designated as critical.

Warmup pads located near the junction of the leading taxiway and the runway must necessarily be classified as critical for very obvious reasons. These pads are provided for the purpose of engine checks, for turning in event of an abort, as a bypass for other aircraft with priority landing and takeoff or for a number of other reasons. In effect warmup pads are subjected to as much severe treatment from jet fuel spillage and more from heat and blast than do the parking areas on the main apron.

Reference to pages 402–403: Reference was made to the new Williams AFB apron and the statement "* * * it had no dan age whatever to it, though it was completely destroyed. Here are the facts:

The apron was built to take care of the large number of jet fighters scheduled for the base training mission. The design was in accordance with the current high-type requirements, but during construction low porosity requirements were not achieved. This resulted in a very porous pavement. Shortly after it was completed a number of transient jet aircraft were parked on the new apron and remained overnight. The following morning a large area (approximately 1 square yard) under each plane was saturated with fuel to such an extent that structural stability was destroyed. Upon receiving reports of damage, representatives of the Directorate of Installations, Hq. USAF investigated the situation. The areas originally damaged had been repaired by replacement with cold patch material. For the benefit of the investigating personnel, a jet aircraft was purposely parked overnight to determine what would happen. As before, an area under the aircraft was saturated with fuel dripping from the overflow pipe. For these reasons the base commander has never permitted jet aircraft to park on the apron. Instead, the apron is used for conventional aircraft. A project to surface the apron with a tar-rubber pavement, for experimental purposes, will get underway sometime during the spring of 1954 after which the apron will be used for parking jet aircraft.

Reference to page 409: For the record it is desired to state that the air installation officer presently assigned to Limestone AFB is a graduate civil engineer and registered as a professional engineer in the District of Columbia.

DEPARTMENT OF THE AIR FORCE,
HEADQUARTERS UNITED STATES AIR FORCE,
Washington 25, D. C., February 20, 1951.

Subject: Criteria for airfield pavement construction at Air Force installations.
To: Chief of Engineers, Department of the Army, Washington 25, D. C.

1. Reference is made to letter from this headquarters to Chief of Engineers, dated January 3, 1951, subject as above.

2. As a further amplification of criteria for airfield pavement construction given in AF Regulation 86–5 dated October 11, 1950, and in the above referenced letter, the following policy is established.

3. When bituminous concrete runways are to be constructed at United States Air Force installations, the outer ends of the runways will be constructed of portland cement concrete. The length of the portland cement concrete at each end of the runway will be a maximum of 1,000 feet and a minimum of 500 feet. In general the 1,000-foot length will be constructed, however, where practical considerations dictate otherwise, the length can be reduced but shall not be less than 500 feet. Warmup pads and fighter alert aprons will also be constructed of portland cement concrete. Any instance in which this procedure appears infeasible, will be referred to this headquarters for decision.

5. The above policy will not apply to those projects in which the design or construction has advanced to a point where the enforcement of this policy would sensibly delay the accomplishment of the work.

For the Chief of Staff:

ALBERT E. STOLTZ,
Colonel, USAF Assistant Deputy Director of Installations Office,
Deputy Chief of Staff, Materiel.

[First endorsement]

Subject: Criteria for airfield pavement construction at Air Force installations.
From: Office of the Chief of Engineers, Washington 25, D. C., March 8, 1951.
To: Chief of Staff, United States Air Force, Washington 25, D. C.

(Attention: Director of Installations, Deputy Chief of Staff, Materiel.)

1. Reference is made to conference your headquarters March 5, 1951, on the subject matter, at which time the following policy was proposed by USAF.

(*a*) No delay on items about to go to contract.

(*b*) Where quality control can be assured, asphalt may be used.

(*c*) Where quality control cannot be assured, portland cement concrete will be used as per basic letter.

(*d*) Runway extensions will usually be constructed conforming to existing materials where answer to 2 (*b*) above is in the affirmative.

(*e*) Operational aprons will usually be portland cement concrete.

(*f*) Warmup pads and alert aprons will be the same as for runways.

2. Comments of this office on the items enumerated in paragraph 1 above are as follows:

(*a*) Items in construction programs authorized to date by your office, including second supplemental program, fiscal year 1951, have advanced to the stage where, in the opinion of this office, a measurable delay and increased cost would be entailed in redesigning any facilities in variance with the provisions of the basic letter.

(*b*) Investigations of the Corps of Engineers over the past several years in asphalt paving design has resulted in perfecting a method for design and control of asphalt paving mixtures which has proven to be capable of not only permitting an adequate quality design but the field control of the mixture during construction. It is the opinion of this office that by applying this method a pavement will result that will not be materially damaged by the normal operation of Air Force jet aircraft now in use. It is the further opinion of this office that this method can be successfully employed anywhere within the continental limits of the United States. Outside the continental limits of the United States there may be some question as to maintaining this standard. Each project of this type will receive individual consideration.

(*c*) This office concurs in the statement contained in paragraph 1 (*c*) above.

(*d*) With reference to paragraph 1 (*d*) above, it appears that cost differentials in some instances may warrant using the lower-cost pavement. If this is desired, request that your headquarters designate percentage of savings to be secured to warrant such change.

(*e*) Concur with paragraph 1 (*a*) above.

(*f*) Concur with paragraph 1 (*f*) above.

3. In consonance with opinions and discussions reported in the preceding paragraphs, it is requested that your headquarters issue a new policy statement, in lieu of the basic letter, and at the same time this information be disseminated to your field installations and liaison officers.

4. It is essential, in order to expedite the Air Force program, that determination of type of pavement be made by the division or district engineer, based on suitable cost estimates derived from local material and cost conditions, prior to proceeding with working drawings and specifications and no alternate designs be required.

For the Chief of Engineers:

G. J. Nold,
Brigadier General, Assistant Chief of Engineers, Military Construction.

October 16, 1953.

Subject: Airfield pavement selection policy.
To: The Chief of Staff, United States Air Force.
(Attention: Director of installations, DCS/O.)

1. In view of the current austerity policy of the Department of Defense and in keeping with our engineering responsibilities, this office desires to comment on the airfield pavement selection policy as presently annunciated by your headquarters.

2. Reference is made to the following:

(*a*) Letter from your office addressed to the Chief of Engineers, file AFMAI–PE–2, dated May 1, 1951, subject: Criteria for airfield pavement construction at Air Force installations.

(*b*) Letter from this office to all division engineers, subject: Criteria for selection of pavement types at Air Force installations, dated May 16, 1951, and amplification of this letter by another letter to all divisions dated July 5, 1951.

(*c*) Memorandum to Maj. Gen. P. W. Timberlake from Brig. Gen. John R. Hardin, subject: Criteria for selection of pavement types at Air Force installations, dated July 16, 1951.

(*d*) Memorandum from Maj. Gen. P. W. Timberlake to Brig. Gen. John R. Hardin, file AFMAI–CEP, subject: Criteria for selection of pavement types at Air Force installations, dated September 24, 1951, with first indorsement thereto dated October 8, 1951.

(*e*) Letter from your headquarters, file AFOAI–CO, dated September 3, 1952, subject: Airfield pavement policy.

(*f*) Letter from your headquarters file AFOAI–CI, dated September 24, 1952, subject: Airfield pavement policy.

(*g*) Paragraph 4 of your first endorsement, file AFOAI–1/4, dated December 29, 1952, in response to our letter of November 28, 1952, subject: Application of fiscal year 1953 pavement policy on certain pavement items in fiscal year 1952. Our interpretation of references (*e*), (*f*), and (*g*) is that the outlined policy is applicable to fiscal year 1953 projects and those projects in fiscal year 1951 or 1952 program not under contract at the time this policy was established.

3. A tabulation of contract awards by the Corps of Engineers on airfield paving has been made covering a 15-month period between February 1, 1952, and May 1, 1953. This tabulation reflected comparative prices of the pavement structure alone for portland cement concrete and bituminous concrete and did not include bid items common to both types such as grading, drainage, and electrical installations. Copies of the complete tabulation were furnished Col. R. H. Curtin of your headquarters and to the Engineering Branch of your Architectural and Engineering Division in June 1953. A summary of the tabulation, also furnished your headquarters, discloses that on a nationwide average the rigid type pavement (portland cement concrete) costs 83 percent more for heavy duty pavements and 90 percent more for light duty pavements that for the equivalent pavements in the flexible type (bituminous).

4. It is our understanding that the reason for specifying a predominance of portland cement concrete is because of the claim of some field commanders that bituminous pavements are unduly damaged from the spillage of fuel and the heat and blast effects of jet aircraft. A field inspection has been made of every instance reported by your headquarters of excessive damage to flexible type pavements by the action of jet aircraft. In addition, numerous other inspections have been made by Corps of Engineers personnel at Air Force bases which have been subjected to intensive use of jet aircraft. In only one instance has appreciable damage caused by normal operation of jet aircraft been observed in flexible type pavements, designed and constructed under current criteria of the Corps of Engineers. This exception was at Williams Air Force Base where poor construction control permitted a void ratio in the finished pavement in excess of that allowed by Corps of Engineers criteria. In a few instances where an excessive accumulation of fuel was allowed to remain on the pavement, some surface softening has taken place. It is the considered opinion of this office that in the majority of cases damage to the pavement, from this cause, could have been avoided and in no case was the damage beyond that which could have been cured by prompt and normal maintenance. It is unlikely that increased maintenance cost of these limited areas could absorb the differences in pavement cost indicated in the summary of awards noted in paragraph 3 above.

5. An investigation has been underway, at the request of your headquarters, for the past year to determine the advantage, if any, of a tar-rubber blend for pavement surfacing to negate the effect of jet aircraft operation on airfield pavements. A tabulation of recent contract awards at four Air Force installations discloses that a 1½-inch surfacing of tar-rubber concrete costs approximately three times as much as the same thickness of the conventional bituminous concrete. In other words, the 1½-inch surface of conventional type could have been applied three times for the cost of the premium material. Further, recent developments during the progress of the investigation into this material have raised some doubts as to its effectiveness.

6. In view of the above and with due regard for economy, the following policy for selection of airfield pavements for fiscal year 1954 and subsequent programs is recommended:

(*a*) One standard should be adopted for both 25-year and 10-year Air Force bases in the Zone of Interior and for installations outside of the United States.

(*b*) Areas indicated below should be designed for portland cement concrete:

(1) Maintenance aprons.

(2) Refueling aprons.

(3) Wash racks.

(*c*) All areas except those enumerated in "b" above should be designed for either portland cement concrete or bituminous concrete on the basis of lowest first cost.

7. In some instances local conditions may dictate the desirability of deviating from the above-recommended policy. In such instances a report setting forth the circumstances would be prepared for decision by Headquarters USAF.

8. In order that full advantage may be taken of the economical aspects and any last minute delay be avoided in carrying out the Air Force construction program, it is requested that early consideration be given to this matter and decision rendered to this office as soon as possible.

For the Chief of Engineers:

DAVID H. TULLEY,
Brigadier General, United States Army,
Assistant Chief of Engineers for Military Construction.

[First endorsement]

ENGER (1 March 1952)

Subject: Criteria for selection of type of pavement at Air Force installations.

From: Office of the Chief of Engineers, Washington 25, D. C., March 13, 1952.

To: The Chief of Staff, United States Air Force.
(Attention: Director of Installations, Office of the Chief of Staff for Operations, AFOAI–CE)

1. The comments of the South Pacific Division engineer, contained in the basic letter, are at considerable variance with the damage to asphalt pavements from fuel spillage and asphalt pavement life reported in the enclosure to the basic letter.

2. Additional information taken from files of this office is noted below:

(*a*) The pavements on Travis Air Force Base, referenced in paragraphs 1 and 2 of enclosure to the basic letter, were designed for 25,000-pound single-wheel load with a contact pressure of 100 pounds per square inch. The area paved was adjacent to the concrete B–36 nose dock hardstands for use by maintenance equipment and light vehicles servicing the B–36 planes.

(*b*) The damage to the Travis Air Force Base pavements, described in paragraph 2 of the enclosure referenced in subparagraph (*a*) above, was caused by continued dripping of fuel from the two jet engines attached to each wing of the B–36 plane. The planes were parked on the concrete hardstands in a manner which projected the jet engines over the light duty asphalt pavements. Continued drippage of fuel composed of approximately 50 percent aromatic fuel and 50 percent lubricating oil from the jet engines damaged the asphalt pavements in a number of spots ranging in area from 10 to 25 square feet.

3. It is the opinion of this office that damage may be expected when asphalt pavements designed for traffic of light vehicles are subjected to continual drippage of fuel of the type described in paragraph 1 (*b*) above.

For the Chief of Engineers:

I. O. THORLEY, JR.,
Acting Chief, Engineering Division, Military Construction.

SPDGG 686.61 (Gen) MARCH 1, 1952.

Subject: Criteria for selection of type of pavement at Air Force installations.

To: Chief of Engineers, Department of the Army, Washington 25, D. C.
(Attention: Engineer.)

1. Reference is made to enclosed copy of letter dated February 25, 1952 from the AFIR, SPD, to Director of Installations. Headquarters United States Air Force, subject: Request for instructions on use of asphalt concrete or portland cement concrete pavements.

(*b*) Letter from this office to all division engineers, subject: Criteria for selection of pavement types at Air Force installations, dated May 16, 1951, and amplification of this letter by another letter to all divisions dated July 5, 1951.

(*c*) Memorandum to Maj. Gen. P. W. Timberlake from Brig. Gen. John R. Hardin, subject: Criteria for selection of pavement types at Air Force installations, dated July 16, 1951.

(*d*) Memorandum from Maj. Gen. P. W. Timberlake to Brig. Gen. John R. Hardin, file AFMAI–CEP, subject: Criteria for selection of pavement types at Air Force installations, dated September 24, 1951, with first indorsement thereto dated October 8, 1951.

(*e*) Letter from your headquarters, file AFOAI–CO, dated September 3, 1952, subject: Airfield pavement policy.

(*f*) Letter from your headquarters file AFOAI–CI, dated September 24, 1952, subject: Airfield pavement policy.

(*g*) Paragraph 4 of your first endorsement, file AFOAI–1/4, dated December 29, 1952, in response to our letter of November 28, 1952, subject: Application of fiscal year 1953 pavement policy on certain pavement items in fiscal year 1952. Our interpretation of references (*e*), (*f*), and (*g*) is that the outlined policy is applicable to fiscal year 1953 projects and those projects in fiscal year 1951 or 1952 program not under contract at the time this policy was established.

3. A tabulation of contract awards by the Corps of Engineers on airfield paving has been made covering a 15-month period between February 1, 1952, and May 1, 1953. This tabulation reflected comparative prices of the pavement structure alone for portland cement concrete and bituminous concrete and did not include bid items common to both types such as grading, drainage, and electrical installations. Copies of the complete tabulation were furnished Col. R. H. Curtin of your headquarters and to the Engineering Branch of your Architectural and Engineering Division in June 1953. A summary of the tabulation, also furnished your headquarters, discloses that on a nationwide average the rigid type pavement (portland cement concrete) costs 83 percent more for heavy duty pavements and 90 percent more for light duty pavements that for the equivalent pavements in the flexible type (bituminous).

4. It is our understanding that the reason for specifying a predominance of portland cement concrete is because of the claim of some field commanders that bituminous pavements are unduly damaged from the spillage of fuel and the heat and blast effects of jet aircraft. A field inspection has been made of every instance reported by your headquarters of excessive damage to flexible type pavements by the action of jet aircraft. In addition, numerous other inspections have been made by Corps of Engineers personnel at Air Force bases which have been subjected to intensive use of jet aircraft. In only one instance has appreciable damage caused by normal operation of jet aircraft been observed in flexible type pavements, designed and constructed under current criteria of the Corps of Engineers. This exception was at Williams Air Force Base where poor construction control permitted a void ratio in the finished pavement in excess of that allowed by Corps of Engineers criteria. In a few instances where an excessive accumulation of fuel was allowed to remain on the pavement, some surface softening has taken place. It is the considered opinion of this office that in the majority of cases damage to the pavement, from this cause, could have been avoided and in no case was the damage beyond that which could have been cured by prompt and normal maintenance. It is unlikely that increased maintenance cost of these limited areas could absorb the differences in pavement cost indicated in the summary of awards noted in paragraph 3 above.

5. An investigation has been underway, at the request of your headquarters, for the past year to determine the advantage, if any, of a tar-rubber blend for pavement surfacing to negate the effect of jet aircraft operation on airfield pavements. A tabulation of recent contract awards at four Air Force installations discloses that a 1½-inch surfacing of tar-rubber concrete costs approximately three times as much as the same thickness of the conventional bituminous concrete. In other words, the 1½-inch surface of conventional type could have been applied three times for the cost of the premium material. Further, recent developments during the progress of the investigation into this material have raised some doubts as to its effectiveness.

6. In view of the above and with due regard for economy, the following policy for selection of airfield pavements for fiscal year 1954 and subsequent programs is recommended:

(*a*) One standard should be adopted for both 25-year and 10-year Air Force bases in the Zone of Interior and for installations outside of the United States.

(*b*) Areas indicated below should be designed for portland cement concrete:

(1) Maintenance aprons.

(2) Refueling aprons.

(3) Wash racks.

(*c*) All areas except those enumerated in "b" above should be designed for either portland cement concrete or bituminous concrete on the basis of lowest first cost.

7. In some instances local conditions may dictate the desirability of deviating from the above-recommended policy. In such instances a report setting forth the circumstances would be prepared for decision by Headquarters USAF.

8. In order that full advantage may be taken of the economical aspects and any last minute delay be avoided in carrying out the Air Force construction program, it is requested that early consideration be given to this matter and decision rendered to this office as soon as possible.

For the Chief of Engineers:

DAVID H. TULLEY,
Brigadier General, United States Army,
Assistant Chief of Engineers for Military Construction.

[First endorsement]

ENGER (1 March 1952)

Subject: Criteria for selection of type of pavement at Air Force installations.

From: Office of the Chief of Engineers, Washington 25, D. C., March 13, 1952.

To: The Chief of Staff, United States Air Force.
(Attention: Director of Installations, Office of the Chief of Staff for Operations, AFOAI–CE)

1. The comments of the South Pacific Division engineer, contained in the basic letter, are at considerable variance with the damage to asphalt pavements from fuel spillage and asphalt pavement life reported in the enclosure to the basic letter.

2. Additional information taken from files of this office is noted below:

(*a*) The pavements on Travis Air Force Base, referenced in paragraphs 1 and 2 of enclosure to the basic letter, were designed for 25,000-pound single-wheel load with a contact pressure of 100 pounds per square inch. The area paved was adjacent to the concrete B–36 nose dock hardstands for use by maintenance equipment and light vehicles servicing the B–36 planes.

(*b*) The damage to the Travis Air Force Base pavements, described in paragraph 2 of the enclosure referenced in subparagraph (*a*) above, was caused by continued dripping of fuel from the two jet engines attached to each wing of the B–36 plane. The planes were parked on the concrete hardstands in a manner which projected the jet engines over the light duty asphalt pavements. Continued drippage of fuel composed of approximately 50 percent aromatic fuel and 50 percent lubricating oil from the jet engines damaged the asphalt pavements in a number of spots ranging in area from 10 to 25 square feet.

3. It is the opinion of this office that damage may be expected when asphalt pavements designed for traffic of light vehicles are subjected to continual drippage of fuel of the type described in paragraph 1 (*b*) above.

For the Chief of Engineers:

I. O. THORLEY, Jr.,
Acting Chief, Engineering Division, Military Construction.

SPDGG 686.61 (Gen) MARCH 1, 1952.

Subject: Criteria for selection of type of pavement at Air Force installations.

To: Chief of Engineers, Department of the Army, Washington 25, D. C.
(Attention: Engineer.)

1. Reference is made to enclosed copy of letter dated February 25, 1952 from the AFIR, SPD, to Director of Installations, Headquarters United States Air Force, subject: Request for instructions on use of asphalt concrete or portland cement concrete pavements.

2. Comments of this office are furnished for your information as follows:

(*a*) *Paragraph 1*

In addition to the pavement construction listed, an additional 1,770,000 square yards of bituminous pavement for aircraft have been constructed as follows:

(1) Williams Air Force Base—Goodyear Auxiliary, 239,000 square yards runway and taxiway

(2) March Air Force Base, 301,000 square yards runway and taxiway under construction

(3) Luke Auxiliary No. 1, 141,000 square yards runway and taxiway

(4) Luke Auxiliary No. 6, 309,000 square yards runway and taxiway

(5) Oxnard Air Force Base, 154,000 square yards runway, taxiway, and apron

(6) Hickam Air Force Base, 272,000 square yards runway and taxiway

(*b*) *Paragraph 2*

(1) A report of the San Francisco District and the Division Laboratory on the pavement at the ends of the runway at Hamilton Air Force Base was forwarded from this office by first endorsement dated August 7, 1951, to basic letter dated July 13, subject: Report on inspection of bituminous pavement, Hamilton Air Force Base. A recent visual inspection of the pavement in question indicated no change from the good condition as previously reported.

(2) Final comment on the pavement at Travis Air Force Base was forwarded to your office by fifth endorsement dated February 21, 1952, to basic letter dated December 13, 1951, subject: Study of Distressed Pavement, Travis Air Force Base. Instead of damage to 110,000 square yards, as stated, the resident engineer on this date stated that the area involved is about 300 square yards by jet fuel and not more than 100 square yards by reciprocating engines.

(3) Comments of this office on the pavement at Williams AFB were forwarded to your office by first endorsement dated January 31, 1952, to basic letter dated January 26, subject: Williams AFB, Contract No. DA–04–353IENG–1313, Damage to Parking Apron. Reference is also made to letter from this office dated January 23, 1952, subject: Inspection of Parking Apron, Williams AFB, which forwarded copy of report by the South Pacific Division Laboratory.

(*c*) *Paragraph 3*

This office has no information as to curtailed use of the areas involved.

(*d*) *Paragraph 4*

Additional pavements are being designed for Travis AFB.

(*e*) *Paragraph 5*

Selection of type of pavement is being made in accordance with criteria established by your office in letter dated July 5, 1951, subject as above.

(*f*) *Paragraph 6*

This office has no information on the various methods of construction, maintenance, or special treatments mentioned.

For the Division Engineer:

F. C. KENDALL,
Chief, Engineering Division.

1 Encl Cy AFIR ltr, February 25, 1952.

FEBRUARY 25, 1952.

Subject: Request for instructions on use of AC or PCC pavements.
To: Director of Installations, DC/S Operations, Headquarters USAF.
From: Air Force Installations Representative, South Pacific Division, Corps of Engineers, 130 Sutter Street, San Francisco, Calif., SPDAF–F.

1. Following the firm policy that first cost is the only consideration for determining the type of pavement wearing surface, this division has constructed within the past year pavement wearing surfaces of asphaltic concrete at the following locations:

(*a*) Hamilton Air Force Base, resurface runway.
(*b*) Johnston Island, runway and taxiway extension.
(*c*) Luke Air Force Base, taxiway and runway extension.
(*d*) Travis Air Force Base, light-duty pavement in hardstand area.
(*e*) Williams Air Force Base, 100,000 square yards of parking apron.

2. Previous reports to Headquarters, USAF, from this office have been to the effect the jet aircraft have damaged the above asphaltic pavements at Hamilton, Travis, and Williams Air Force Bases. The damage at Hamilton is located at the ends of the runways and is caused by fuel spillage, exhaust heat, and exhaust velocity. The area visually damaged is approximately 200 square yards. At Travis, all of the damage has been caused by fuel spillage and impingement, followed by migration of jet fuels and lubricants into the surrounding base course. The extent of the damage at Travis is estimated at 100,000 square yards, damage by jet fuel plus 10,000 square yards damage by reciprocating engines of B–36's. At Williams Air Force Base the entire damage is due to jet-fuel spillage and impingement. The area affected is less than 100 square yards, however, the base commander has ordered that the parking apron remain out of use until such a time as a suitable overlay has been placed.

3. At Hamilton, Travis, and Williams Air Force Bases, the operations of the base are curtailed due to the above-described conditions. Tandem takeoffs are prohibited at Hamilton, stands for engine repair are difficult to maneuver at Travis; and no aircraft are allowed on the apron at Williams Air Force Base. In addition, the respective AIO's are required to take action to repair and maintain the pavements; this requires frequent replacement with AC, or substitution of PCC.

4. The following pavements of asphaltic concrete are presently either being designed or are under construction by the South Pacific division:

(*a*) Davis-Monthan, runway, taxiway, fueling area, and parking apron.
(*b*) Edwards, runway, taxiway, and parking apron.
(*c*) George, runway and taxiway extension.
(*d*) Hickam, taxiway and parking apron.
(*e*) March, runway, taxiway, and parking apron.
(*f*) Mather, parking apron.
(*g*) McClellan, parking apron.
(*h*) Nellis, runway.
(*i*) Williams, runway and taxiway extension.

5. Since damaged pavements interfere with the mission of the base, and since the life of new AC pavements in certain locations has been less than 1 year, it is recommended that the following locations be constructed of PCC pavement:

(*a*) All parking aprons used for anything except dead storage.
(*b*) The first 500 feet of each runway.
(*c*) All warmup, or arming pads.
(*d*) All fueling areas.
(*e*) Where existing runways and taxiways are of PCE, extensions should be of PCC.

6. The above recommendation is based on the experience of this division over the past year. Various methods of construction, maintenance or special treatments have been tested and tried extensively, and in no case has a solution been found which would prolong the life of the pavement beyond 3 or 4 months.

7. It is requested, therefore, that the Corps of Engineers be instructed to construct PCC pavements in the above recommended areas.

JAMES A. BARNETT,
Colonel, USAF, Air Force Installations Representative, South Pacific Division.

JULY 24, 1952.

SADBP 600.17 (Reed)
Subject: Inspection of apron pavement—Pinecastle AFB.
To: The Chief of Engineers, Department of the Army, Washington 25, D. C.
(Attention: Engineer.)

As requested by Mr. Gayle McFadden, there is attached a copy of report of inspection of the subject facility by a representative of this office.

For the division engineer:

GEORGE H. MITTENDORF,
Acting Chief, Engineering Division.

1. Incl (dup) Cy Rept of Insp.

43649—54——14

AUGUST 1, 1952.

ENGER
Subject: Investigation on effect of jet aircraft blast and jet fuel spillage on aircraft on airfield pavement.
To: The Chief of Staff, United States Air Force.
(Attention: Director of Installations, Office, Deputy Chief of Staff for Operations.)

1. The South Atlantic division engineer was requested to investigate reports that pavements at Pinecastle Air Force Base, Fla., and Maxwell Air Force Base, Ala., had been damaged by the operation of jet aircraft.

2. Enclosed for your information are copies of inspection reports covering airfields referenced in paragraph 1 above.

3. The Navy F7U-type jet aircraft, described in paragraph 2f of enclosure 2, subjects pavements to temperatures ranging from 500 to over 700° F., depending upon length of time the plane is in a stationary position and the percentage of full throttle being employed.

4. The damage to asphalt pavements from jet blast, as described in paragraph 2c of enclosure 2, may be expected when pavements are subjected to range of temperatures referenced in paragraph 3 above.

For the Chief of Engineers:

H. B. ZACHRISON,
Chief, Engineering Division, Military Construction.

2 Incl.: 1. Cy Insp Rpt Pinecastle AFB; 2. Cy Insp Rpt w/1 ind Maxwell AFB.

JULY 24, 1952.

SADBP-600.17
Memorandum for: Chief, Engineering Division, SAD
Subject: Inspection of apron pavement—Pinecastle AFB.

1. Inspection of the subject facility was made July 18, 1952, at the request of Mr. Gayle McFadden, OCE, to investigate reported damage caused by the operation of jet aircraft.

2. The following observations were made:

(*a*) The apron was completed in January 1952 and consists of 393,000 square yards of flexible pavement and 90,000 square yards of concrete pavement. The surface of the flexible pavement consists of 4-inch hot mixed asphaltic concrete.

(*b*) Sixty-five T-33 type jet aircraft have been based on the field since April 1952 and average 100 cycles of operations per day. An average of 100 fueling operations per day are accomplished on the concrete portion of the apron. When the base reaches full strength, the majority of fueling operations will necessarily take place on bituminous paved areas. One fueling operation from tank truck was observed in which fuel was spilled in four areas, one of which was at the truck.

(*c*) Approximately 150 slightly damaged areas were noted on the asphalt pavement ranging from 4 to 18 inches in diameter. The bituminous mixture in these areas had been dissolved and coarse aggregate was exposed to a depth of one-fourth inch. These damaged areas appeared to have been caused by overflow from plane fuel tanks due to expansion of fuel in hot weather. One small area in which the coarse aggregate was exposed to a depth of one-half inch appeared to have been damaged by jet blast. Several very slightly damaged areas approximately 15 by 50 feet in size were caused by loss of fuel when tanks dropped from planes. Some slight softening of pavement has been caused by excessive spillage of oil and fuel during maintenance and repair operations; however, no displacement has occurred.

(*d*) The runway and taxiway pavements have not been affected by aircraft operation.

(*e*) Outside of the above-noted areas, the pavement is in good condition. Laboratory reports indicate the pavement has the following average properties:

Bitumen (percent)	6.1	Voids filled (percent)	71.3
Stability	2,279	Density	141.3
Flow	10.4	Theo. density	149.1
Total voids (percent)	5.2		

3. The apron pavement has not been damaged to the extent that repair is necessary to date.

G. C. REED, Jr.

[First endorsement]

SADBP–686 Maxwell AFB (30 Jun 52)
Subject: Inspection of pavements, Maxwell AFB, Montgomery, Ala.
From: Office, Division Engineer, South Atlantic Division, Atlanta, Ga., July 15, 1952
To: The Chief of Engineers, Department of the Army, Washington 25, D. C.
(Attention: Enger.)

1. Attached is copy of report of inspection of the subject airfield by a representative of this office.

2. There is no necessity for making any analysis of the pavements since the damage to the pavements is not severe and all pertinent information is available in the pavement evaluation report.

For the division engineer:

C. P. LINDNER,
Chief, Engineering Division.

1 encl: Copy of inspectors report.

JULY 15, 1952.

SADBP–600.17 (Reed)
Memorandum for: Chief, Engineering Division, SAD
Subject: Inspection of pavements, Maxwell AFB, Montgomery, Ala.

1. Inspection of airfield pavements at the subject facility was made July 11, 1952, to determine the extent of reported damage to pavements as a result of jet aircraft operation. The inspection was made in company with Lt. Col. C. A. Trotter, base operations officer, Capt. R. H. Blain, assistant AIO, and representatives of the AFIR office, SAD.

2. The following observations were made:

a. Pavements consist of portland cement concrete and hot-mixed asphaltic concrete.

b. The airfield pavements were reinforced and/or reconstructed between June 1945 and January 1946.

c. Refer to the airfield pavement capacities study dated April 1947 for location of the following areas damaged by jet blast:

(1) Southeast end of NW/SE runway and adjacent taxiway warmup area. (A. C. pavement.)

(a) Two dual areas in which seal coat has been removed.

(b) Two dual areas in which surface course aggregate is exposed one-quarter inch.

(c) Five dual areas in which surface course aggregate is exposed one-half inch.

(d) One single area in which surface course aggregate is exposed one-half inch.

(2) South end of NS runway and adjacent taxiway warmup area. (A. C. pavement.)

(a) Six dual areas in which seal coat has been removed.

(b) 6 dual areas in which surface course aggregate is exposed one-fourth inch.

(c) 1 dual area in which surface course aggregate is exposed one-half inch.

(d) 1 single area in which surface course aggregate is exposed one-half inch.

(3) Taxiway No. 4 (A. C. pavement): 1 dual area in which the surface course aggregate is exposed three-fourths inch.

(4) Warmup pad at northwest end of NW/SE runway (portland cement concrete pavement): Two areas (approximately 8 feet diameter) with excessive crazing due to heat blast. One area slightly pitted.

(5) North end of NS runway (P. C. concrete pavement): Slight damage to joint material due to heat and blast.

(6) Subdepot apron (P. C. concrete pavement): Some surface crazing due to heat blast.

(7) All damage to asphaltic concrete pavements except two single areas is reflected in dual elliptical burned areas 5 feet center to center with each approximating 2½ feet x 5 feet in dimension.

d. The burned areas in the bituminous pavements should be painted with a tack coat and leveled up with sand asphalt. A rough estimate of cost for complete repair is $50.

e. The damaged pavements were in good condition prior to operation of jet aircraft.

f. Jet aircraft are not regularly based at Maxwell AFB. During June 1951 10 F–80 and F–84 planes operated from the field on special mission for approximately 2 weeks. All types of transient jet aircraft are fueled at this field. From the evidence at hand, approximately 95 percent of all damage by blast has been caused by Navy Cutlass F7U type aircraft.

g. All available information relative to pavement densities, gradation and bitumen content is contained in the pavement evaluation report.

h. There is no damage caused by spillage of jet fuel. The fuel spillage damage reported in letter to your office dated July 6, 1952, subject: "Inspection of Airfield Pavements, Maxwell Air Force Base, Ala.," has completely cured out except for discoloration.

i. There is no necessity for making any analysis of the pavement. Sufficient pertinent data are available in pavement evaluation report.

j. Based on visual inspection of undamaged areas, the asphaltic concrete pavements are in excellent condition except for isolated cracking and some opening of longitudinal construction joints.

G. C. REED, Jr.

ENGER JUNE 25, 1952.

Subject: Investigation of Distressed Pavement, Hickam Air Force Base
To: Chief of Staff, United States Air Force

(Attention: Director of Installations, Office of the Deputy Chief of Staff for operations.)

1. The San Francisco district engineer investigated a report that asphalt pavements on the subject airfield had been severely damaged by blast of jet aircraft.

2. The investigation disclosed that—

(*a*) The pavement was a hot-mix asphaltic concrete, 2 inches thick, constructed in 1944 and resurfaced with one-half inch of asphaltic concrete (fine aggregate type three-eights inch maximum size) in 1951.

(*b*) Part of the one-half inch resurfacing course was blown off in two areas approximately 5 by 20 feet.

(*c*) The underlying pavement had not been damaged based on analyses of cores taken in damaged areas and adjacent to the damaged areas.

(*d*) No further deterioration of pavement has occurred since the damage described above in subparagraph (*b*) above.

(*e*) There had been very limited operation of B–45 and B–47 jet aircraft up to December 1951, on the subject airfield.

(*f*) Type JP–1 jet fuel was in use.

(*g*) The investigators were unable to determine which type of aircraft caused the damage.

3. The damaged areas are typical of deterioration to asphaltic concrete pavements caused by blast of B–45 jet aircraft during recent special tests conducted at Eglin Air Force Base, Fla.

4. It is the opinion of this office that:

(*a*) The small damaged areas may be readily repaired during normal maintenance operations.

(*b*) The damage may have been caused by B–45 jet aircraft which this office understands is now obsolete.

(*c*) The fine aggregate type asphaltic concrete resurfacing course is more susceptible to deterioration from jet aircraft blast than the thicker underlying asphaltic concrete course containing 1-inch maximum size aggregate.

By order of the Chief of Engineers:

H. B. ZACHRISON,
Chief, Engineering Division, Military Construction.

ENGER AUGUST 22, 1951.

Subject: Investigations on Effect of Jet Aircraft Blast and Jet Fuel Spillage on Airfields Pavement
To: The Chief of Staff, United States Air Force
Attention: Director of Installations Office, Deputy Chief of Staff, Materiel

1. Reference is made to letter OCE to Chief of Staff, United States Air Force, subject same as above, dated August 16, 1951.

2. The airfields described below supplement the list shown in paragraph 2 of the letter referenced in paragraph 1 above.

3. Three airfields are listed below together with a brief description of the effect of jet aircraft operations on existing asphalt pavements.

(*a*) Luke Air Force Base, Arizona. The only runway paved with asphalt consists of a temporary landing strip constructed in February 1951. The strip has been subjected to about 1,750 cycles of jet aircraft operation a month for the last 6 months. Part of the strip consists of existing concrete pavement. The remainder was constructed by leveling up with hot-mix asphalt concrete a portion of an existing mat which was paved with 2 inches of mixed-in-place asphalt pavement on 5 inches of pit-run gravel. The strip was surfaced with an inch of hot-mix pavement using a slow curing grade of asphaltic oil (SC–4). The surface course is very soft and shows evidence that an excessive amount of oil was used. The pavement does not conform in any way to the Corps of Engineers criteria for hot-mix asphaltic concrete now being used for construction of runways. There was no visual evidence of damage to the pavement from blast or jet-fuel spillage.

(*b*) Hamilton Air Force Base, Calif. The existing concrete-paved runway 12–30 was overlaid with 2 inches of hot-mix asphalt concrete the latter part of 1950. The pavement is subjected to an average of 70 daily flights of F–84 type jet aircraft and occasional use by other types of jet aircraft. Laboratory examination of sample cores taken from existing pavement indicates conformance to current pavement criteria. There is no evidence of damage from spillage of jet fuel or blast.

(*c*) Geiger Field, Wash. The location, type of pavement, and extent of damage are described below:

(1) Most of the bituminous surface treatment (about one-half inch in thickness) constructed on the stabilized shoulder of taxiway A has been blown off by blast of jet aircraft. Surface treatements are very thin and generally considered to be a temporary type of construction subject to considerable maintenance.

(2) A portion of the overrun area at the south end of runway No. 6 was surfaced with a single surface treatment and subsequently patched with hot-plant mix. The treatment was placed on the existing soil and varied from one-half to 1½ inches in thickness. The jet aircraft blast has blown off a large portion of the surface. The bituminous surfacing used on the overrun area does not conform to current pavement criteria in any way.

(3) Taxiways 1 and 2 are paved with 4 inches and 3 inches of hot-mix asphaltic concrete respectively on a high quality base course. The pavements which were constructed in 1942 show no visual evidence of damage from blast or jet fuel spillage.

4. Information on other airfield pavements which are being inspected will be forwarded to your office as soon as practicable.

For the Chief of Engineers:

F. S. POORMAN,
Deputy Chief, Engineering Division, Military Construction.

MARCH 6, 1951.

ENGER
Subject: Inspection report, Elgin Field, Fla.
To: The Chief of Staff, United States Air Force.

(Attention: Director of Installations Office, Deputy Chief of Staff, Materiel Construction Division, Operations Branch (AFMAI CO).)

Forwarded for your information is a copy of inspection report prepared by a representative of this office in connection with the effect of jet aircraft operation on pavements.

For the Chief of Engineers:

F. S. POORMAN,
Deputy Chief, Engineering Division, Military Construction.

1 Enclosure: Inspection report.

Inspection Report of Mr. Walter C. Ricketts

To: Chief, Engineering Division.

A. Place and date

Eglin Field, Fla., February 19, 20, 21, 22, 1951.

B. Purpose

To witness tests in connection with protective coatings to resist effect of jet aircraft operations and to inspect existing pavements for possible damage from spillage of jet fuel.

C. Authority and clearance

USAF requested a representative of this office to accompany representatives of Air Force on the inspection.

D. Narrative

Lieutenant Colonel Houck, Installations Office [1]
Mr. Robert Johnson, Deputy, Installations Office [1]
Mr. Earl Schroeder, Installations Office [1]
Mr. John C. Burton, USAF.
Mr. L. Matson, USAF
Mr. Walter C. Ricketts, OCE

1. Electrical equipment for recording temperatures was placed on the section of pavement treated with Jennite M–38, referenced in paragraph 6 of the attached summary.

2. The section was subjected to exhaust of a F–80 jet plane for 25 minutes at idling speed, and 5 minutes at full throttle. The top temperature recorded was 300° F., and the air temperature was 72° F. The exhaust at full throttle blew the Jennitte off the surface of the pavement. In some spots the surface of the pavement was also blown off to a depth of about one-fourth inch.

3. The F–80 was selected for the test as the plane is similar to both F–84 and F–86 (in design), and the F–80 exhaust blast would be representative of the group.

4. The electrical equipment for recording temperatures was transferred to the section of pavement treated with Meco, referenced in paragraph 7 of the attached summary.

5. The section was subjected to exhaust of a F–94 jet plane for 10 minutes at idling speed, full throttle, for 6 minutes and after burner was thrown on for 4 minutes. The temperature recorded at full blast ranged up to 235° F. Maximum temperatures recorded with after burner turned on was 390° F. The exhaust with the after burner turned on blew the Meco off the surface of the pavement. The surface of the pavement was also blown off in some spots to a depth of about one-fourth inch.

6. An inspection of the pavements constructed on auxiliary airfields No. 2 and 3 was made. The runways are paved with mixed-in-place sand asphalt. In order to protect the pavements against effect of spillages of jet fuel the pavements were surface-treated with about 0.25 gallons per square yard of tar grade RT–12 using sufficient three-eighths inch slag to blot up tar.

7. The pavements had been subjected to considerable traffic on the F type jet planes. During a time when a number of jet planes were operating off the fields, Mr. Burton stated that the heat from the planes softened the tar seal sufficiently for the wheels to pick up the tar.

8. An inspection of the ends of the runways on both fields indicated that—

(*a*) The tar seal was entirely removed by the wheels in some areas, exposing the pavement.

(*b*) The tar had been overheated and was very brittle. In some cases the tar seal showed an alligator pattern typical of overheated material.

(*c*) There was no evidence of damage due to jet fuel spillage.

9. An inspection was made of north end of the north-south runway on Eglin Field which is surfaced with a well-designed, well-constructed, hot-mix asphaltic concrete pavement 3 inches in thickness, sealed with about 0.25 gallons per square yard of asphalt (85–100 ———) and three-eighth inch slag. The runway is subjected to considerable traffic of all types of jet aircraft. There was no evidence of damage due to heat or spillage of jet fuel. On one spot, the seal coat was rather dull in appearance which may have been due to high heat. However, there was no evidence of damage to the underlying pavement.

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[1] These parties were not present at all times during the inspection.

10. As mixed-in-place, sand asphalt is considered to be inferior to a well-designed hot-mix asphaltic concrete pavement, a test as described in the next paragraph was made.

11. A section of apron paved with the same type of pavement described in paragraph 9 above was subjected to the blast of a F–94 jet plane for about 2 minutes idling speed, 2 minutes at full speed, and 2 minutes with afterburner turned on. The after burner softened the seal coat slightly, but did not damage the underlying pavement.

1. Conversations with jet-plane pilots and installations personnel indicate that:

(*a*) The normal spillages of jet fuel softens the surface of a well-designed hot-mix asphaltic concrete slightly. However, as the fuel evaporates or is washed off by rain, the asphalt returns nearly to its original penetration.

(*b*) JP–3 jet fuel which may be classified as low grade gasoline was in general use at Eglin Field.

(*c*) Jet planes do not require a warmup period prior to taking off. The normal procedure is to bring the engine up to near starting speed to check performance and then take off. This requires about 30 seconds to 1 minute and in normal operation, the maximum time that plane would stand in one spot should range from 1 to 2 minutes.

(*d*) Normally the afterburner is not turned on in F–94 operations when the plane is on the ground.

13. During the final conference with Lieutenant Colonel Houck on February 22, 1951, Mr. Burton requested that the section of pavement described in paragraph 5 of the attached summary be subjected to exhaust of jet aircraft.

14. Complete information regarding the B–47, a new type jet-propelled aircraft, could not be obtained as all planes and personnel familiar with B–47 operations were absent from Eglin Field during the inspection. However, information presently available indicates that the B–47 will not present any problem in connection with asphalt-pavement construction.

15. It was pointed out to Air Force personnel in connection with the test described in paragraph D2 and D4 above, and the inspection of the tar seal coats on Nos. 2 and 3 airfields that tar products used for paving become very fluid at temperatures around 200° F., and are damaged when heated to temperatures over about 250° F. Further, while tar was only slightly soluble in jet fuel, any thin surface treatment would be worn off rapidly by traffic and could only be considered to be a temporary expedient.

E. Conclusions

1. The two types of plastic material and the tar product described in paragraphs 2, 3, and 4 of the attached summary are considered to be unsatisfactory for the protection of asphalt pavement from damage by operation of jet aircraft.

2. While the test section of Jennite M–38 described in paragraph 6 of the attached summary and paragraph D2 above was subjected to conditions, perhaps, a little more severe than normal, the material became overheated, softened and blew off the pavement surface.

In view of the above, this material could not be considered to be satisfactory as a protective agent.

3. The comments contained in paragraph E2 above are applicable to Meco described in paragraph 7 of the attached summary and paragraph D5 above.

4. The tar seals described in paragraph D6 above are not considered satisfactory as a protective agent against heat generated by normal jet plane operation.

5. Properly designed, well constructed, dense graded, hot mix asphaltic concrete pavements are not materially damaged by spillages of jet fuel or heat from normal operation of F–80, F–84, F–86, and F–94 jet aircraft.

6. In event a high quality, hot mix asphaltic concrete pavement is subjected to long periods of exhaust blast of F–94 at full throttle with after burner turned on damage will result as exhaust temperature exceeds the laying temperature which range from 325° F. to 350° F.

F. Recommendations

1. No further consideration be given to the use of tar seal costs or thin surface treatments of tar or similar materials for protecting well designed asphaltic concrete pavements against effect of heat and jet fuel spillage from current jet aircraft traffic; namely, F–80, F–84, F–86, and F–94.

2. Concrete and flexible type (well designed asphaltic concrete) pavements be selected on a cost basis for use in paving airfields facilities subjected to traffic of types of jet aircraft referenced in paragraph F2 above.

3. Complete information regarding the B–47 jet plane as related to pavement construction be obtained as soon as practicable.

G. Action taken

Copies of this report have been prepared for transmittal to Air Force, Flexible Pavement Laboratory, Rigid Pavement Laboratory, and Washington District Engineer.

WALTER C. RICKETTS,
Chief, Runways Section Airfields Branch.

SUMMARY OF REPORT ON TEST PANELS CONSTRUCTED BY AIR FORCE AT EGLIN FIELD, FLA., ON NORTHWEST END OF NORTHWEST-SOUTHEAST RUNWAY

(Prepared by Mr. Earl Schroeder)

1. *General.*—The pavement on which all coatings described below were placed consists of 5-inch mixed-in-place sand asphalt using RC–15 (Florida Spce). The bitumen content was 4.71 percent, and the density was 79 percent of theoretical. The pavement was treated with a seal coat consisting of about 0.2 gallon of asphalt (85–100) and three-eighths of 1 inch slag chips about 2 years ago.

2. Four areas were treated by squeegee method with P. R. Plastic Seal manufactured by Permanent Roadways, Inc., of Rochester, N. Y. The material was thin, watery, and contained the usual type lacquer thinner. The cost of the material ranged from $4.68 to $5.45 per gallon, depending on quantities.

The material did not adhere to the damp section of the pavement, and when applied in thick films, bubbles formed in film.

One section 9½ feet by 27 feet treated with approximately 10 gallons of the material on January 31, 1951, was submitted to exhaust of an F–80 jet plane on February 6, 1951.

The treated section was subjected to exhaust at idling speed for 4 minutes and at full speed for 5 minutes. The material softened slightly, but did not become tacky. An examination of the underlying pavement indicated that the pavement had absorbed and retained the volatile portion of the material. The thinner softened the pavement materially.

Jet fuel was poured on the pavement from time to time.

3. A section about 9½ feet by 29 feet was treated with a product AGC, manufactured by Permanent Roadways, Inc., Rochester. Six gallons were used on the area applied by squeegee method. The material was similar to P. R. Plastic and cost about $4.25 a gallon.

On January 31, 1951, the treated section was subjected to exhaust of F–80 jet planes for 5 minutes at idling speed and for 5 minutes at full speed.

The blast blew off a very few patches and softened the material.

Jet fuel was poured on the pavement from time to time.

4. A section 9 feet by 29 feet was treated with 3 gallons of Barrett Tarvia Gel manufactured by Allied Dye & Chemical Corp., New York, N. Y., by the squeegee method on January 31, 1951. The material was a specially processed tar, costing about $1.65 a gallon.

On February 6, 1950, the treated section was subjected to exhaust blast of F–80 jet plane for 5 minutes at idling speed and for 3 minutes at full speed. The test was discontinued as the blast removed the tar from the pavement surface.

5. A section about 30 feet by 35 feet was treated with Tar Pet, manufactured by Reilly Tar & Chemical Co., Indianapolis, Ind., by the squeeze method on February 13, 1951. The material was a water emulsion of tar.

The treated section has not been subjected to exhaust blasts of jet aircraft as of this date.

6. A section about 30 feet by 35 feet was treated with Jennite M–38, manufactured by Maintennace, Inc., Wooster, Ohio, on February 7, 1951. The material is a water emulsion of tar pitch, and contained an antifreeze ingredient.

About 35 gallons were used. It is estimated that the application was made at about .26 gallon per square yard. The final film is very thin as the material contains about 40 percent water.

Jet fuel was poured on the section from time to time.

7. A section about 30 feet by 35 feet was treated with Meco, manufactured by Maintenance Engineering Co., Philadelphia, Pa., in two broom coats on February 12, 1951. The material is a water emulsion of tar. About 35 gallons were used. It is estimated that the material was applied at about .26 gallon per square yard. The final film was very thin as the material was thinned with water prior to application.

Jet fuel had been poured on the section from time to time.

CORPS OF ENGINEERS, UNITED STATES ARMY,
OFFICE OF THE DISTRICT ENGINEER,
JACKSONVILLE DISTRICT,
Jacksonville, Fla., April 3, 1951.

SAKMP 686.61 (Jax Airfield, Fla.)
Subject: Inspection of pavements, Jacksonville Airfield, Jacksonville, Fla.
To: The division engineer, South Atlantic division, Atlanta, Ga.

Enclosed are copies of report of inspection of pavements, Jacksonville Airfield No. 1 (Imeson Airport), as requested in your letter dated March 20, 1951, subject: Inspection of Pavements—Hunter Airfield, Savannah, Ga., and Jacksonville Airfield, Jacksonville, Fla.

For the district engineer:

LEO L. BURNET,
Chief, Engineering Division.

1 Inclosure, report, as stated (in trip.).

REPORT OF INSPECTION OF PAVEMENTS, JACKSONVILLE AIRFIELD NO. 1 (IMESON AIRPORT)

1. On Saturday, March 24, 1951, the undersigned made an inspection of the Jacksonville Airfield to determine extent of damage due to spillage of jet fuel and from operation of jet aircraft.

2. Type of pavements: This field has concrete paved areas, bituminous pavement, and bituminous surface treatments. Since any jet damage would be to the bituminous pavements, these pavements will be described and discussed:

(*a*) The northeast-southwest runway, station 3+00 to 49+00; northwest-southeast runway, station 30+00 to station 68+00; east-west runway, station 32+00 to station 64+25; north-south runway No. 1, station 13+00 to 43+00 were originally paved with a 6-inch sand bituminous base course with a 1¼-inch bituminous wearing course.

(*b*) Apron D–1 was paved with a 6-inch compacted shell base with a single bituminous surface treatment.

(*c*) The northwest-southeast runway, station 20+00 to 30+00; east-west runway, station 20+00 to 32+00; north-south runway No. 1, station 0+00 to 10+00 were constructed with a 6-inch compacted limerock base and a 1¼-inch bituminous pavement.

(*d*) All runways were strengthened as follows: Northeast-southwest runway, station 3+00 to 40+00; northwest-southeast runway, station 20+00 to 68+00; east-west runway, station 20+00 to 64+25; north-south runway, station 8+00 to 10+00 and 13+00 to 43+00. These pavements were strengthened by the addition of 7 inches of compacted limerock and 3 inches of asphaltic concrete (hot mix) placed with a 1½-inch binder course and a 1½-inch wearing course.

(*e*) The airfield evaluation report on file in your office shows locations and types of pavements.

(*f*) The age of the above pavements after the strengthening indicated in subparagraph 2d is approximately 9 years.

(*g*) From information at the field, it was indicated that the jet plane activity was confined to the south end of apron D–1 and the northeast-southwest runway. From visual inspection, there is no evidence as to damage from either jet fuel spillage or blast.

(*h*) The joints in the concrete pavement were in poor condition, and should be cleaned and resealed. There is considerable spalling due to lack of maintenance.

(*i*) There is considerable cracking in the asphaltic concrete wearing course and all asphaltic surfaces should be sealed immediately.

(*j*) On the extreme south end of apron D–1 there is a small section of pavement that has completely failed due to the subgrade giving way.

(*k*) Jet planes began operation on this field about December 1948, and stopped operations in October 1950. The number and type of jet craft using this field were as follows: 2 C47's, 21 F80's, 4 PT13's.

(*l*) The jet fuel in use by these planes was J. P. 1.

(*m*) At the present time the field is used by commercial planes, with an occasional military plane landing and using the hanger reserved for the National Guard Unit. Unless this field is to be reactivated in the near future, it is believed that inspection by personnel from OCE is not necessary.

FRANK C. ROBINSON,
Civil Engineer (paving).

AUGUST 16, 1951.

ENGER

Subject: Investigations on Effect of Jet Aircraft Blast and Jet Fuel Spillage on Airfield Pavements.

To: Chief of Staff, United States Air Force.
(Attention: Director of Installations, Office Deputy Chief of Staff, Material.)

1. Inspections have been made of pavements on a number of airfields in connection with the subject investigations. Most of the airfield pavements, listed below, were reported informally by Air Force personnel to be damaged by jet aircraft operations.

2. The airfields inspected to date are listed below together with a brief description of the effect of jet aircraft operation on existing asphalt pavements.

(*a*) Elgin AFB, Florida, no damage.

(*b*) Jacksonville Airfield, Jacksonville, Fla., no damage.

(*c*) O'Hare AFB, Chicago, Ill., no damage except a very few spots varying in diameter from a few inches to 24 inches. The extent of the damage was considered minor in nature.

(*d*) New Castle AFB, Delaware, no damage.

(*e*) Dow Field, Bangor, Maine, no damage.

(*f*) Truax Airfield, Madison, Wis., no damage.

(*g*) Hunter AFB, Savannah, Ga., no damage, except a few small spots which may be readily repaired by normal maintenance.

3. Information on other airfield pavements which are now being inspected will be forwarded to your office as soon as practicable.

For the Chief of Engineers:

F. S. POORMAN,
Deputy Chief, Engineering Division Military Construction.

MARCH 21, 1951.

ENGER

Memorandum for: Chief of Staff, Headquarters USAF. Attention: Director of Installations, Office, Deputy Chief of Staff, Materiel Construction Division, Operations Branch AFMAL–CO.

Subject: Inspection of bituminous pavements, New Castle Air Force Base, Delaware.

Enclosed for your information is a copy of an inspection report on the bituminous pavements at the subject airfield.

For the Chief of Engineers:

A. S. KURTZ,
Assistant Chief for Air Force Projects,
Engineering Division, Military Construction.

1 Encl Cy Inspection Report.

INSPECTION REPORT OF MR. WALTER C. RICKETTS

To: Chief, Engineering Division.

A. Place and date

New Castle AFB, Delaware, March 13, 1951.

B. Purpose

To inspect bituminous pavements on New Castle AFB and determine possible damage from operation of jet aircraft.

C. Authority and clearance

Travel order authorization, dated March 7, 1951.

D. Narrative

Parties present:

Col. L. B. Mackell, commanding officer[1]
Lt. Col. Gandy, air installations officer
Captain Hippler, assistant air installations officer
Mr. H. B. McVaugh, Philadelphia District office
Mr. W. I. Risley, Philadelphia District office
Mr. A. J. Depman, Philadelphia District office
Mr. S. E. Orbacs, North Atlantic Division office
Mr. Walter Newton, County Airport engineer
Mr. Walter C. Ricketts, OCE

[1] Colonel Mackell was not present during inspection of pavements.

1. Colonel Mackell instructed Lieutenant Colonel Gandy to show Corps of Engineers representatives all the pavements which were subjected to traffic of jet aircraft and to consult with Mr. Newton regarding history of the pavements.

2. All runways and taxiways were paved with hot plant mix asphaltic concrete ranging in thickness from 2 inches plus to 1½ inches in thickness. The base course consists of dry bound macadam ranging from 4 to 8 inches. The subbase was a good quality sand gravel. The aprons were paved with concrete. Most of the pavements were constructed in 1942 and 1943.

3. The aggregate used for producing the hot plant mix asphalt pavements was rounded gravel reasonably well graded, sand and asphalt (135 Pen.). The pavements could be classified as dense graded.

4. In September 1949, all the asphalt pavements were surface treated with a .22 gallon per square yard of asphalt emulsion followed by 10 pounds per square yard of fine stone chips. All cracks one sixteenth of inch or greater were filled with asphalt emulsion prior to applying the surface treatment.

5. The condition of the pavement prior to the application of the surface treatment referenced in paragraph 4 above could be considered good, as the number of large cracks was limited and the number of hair cracks was not excessive. The surface treatment sealed all crecks and the present condition is considered to be satisfactory.

6. A group consisting of 20 F–84 jet planes has been stationed on the field since March 1950. Another group consisting of 20 F–86 used the field for about 3 months in 1950. It is estimated that the pavements have been subjected to about 100 cycles a day of jet aircraft.

7. As the jet-aircraft traffic is confined largely to N–S and E–W runways and adjacent taxiways, an inspection was made of these pavements.

8. A section 100 by 200 feet at the north end of the N–S runway had been treated with one brush coat Jennite, a water emulsion of tar, in July 1950.

9. The inspection disclosed that:

(*a*) The pavements were not damaged from spillages of jet fuel. Type JP–3 jet fuel is being used on the field.

(*b*) The only evidence of effect of blast was a limited number of spots which appeared to be only slightly damaged. An examination disclosed that the seal coat had apparently been softened by blast. However, the underlying pavement was not damaged in any respect.

(*c*) The thin Jennite surface treatment had either been removed by blast or worn off by traffic in spots.

10. The damage to the concrete aprons consisted of removal of the asphalt joint sealer from the joints by jet-aircraft blast in a few spots. There was no evidence of other damage.

E. Conclusions

The dense-graded hot-mix asphalt-concrete pavements were not damaged by either blast or spillages of jet fuel from operation of F–84 and F–86 jet aircraft extending over a period of nearly 1 year.

F. Recommendations

None.

G. Action taken

Copies of this report have been prepared for Air Force, flexible pavement laboratory, rigid pavement laboratory, and Philadelphia District engineer.

WALTER C. RICKETTS,
Chief, Runways Section, Airfields Branch.

[First endorsement]

MAY 1, 1951.

Subject: Inspection of bituminous pavement, Truax Airfield, Madison, Wis. (OCE letter to GLD dated April 18, 1951, file ENGER).

GLDGL

From: Office, Division Engineer, Great Lakes Division, Corps of Engineers, Chicago 15, Ill.

To: Chief of Engineers, United States Army, Washington, D. C.

1. On April 24, 1951, Mr. Davis, of this office, inspected the bituminous pavements at Truax Airfield, Madison, Wis.

2. There was no evidence of damage caused by blast or spillage of jet fuel from the operation of F–80 aircraft. However, there has been excessive damage and wear to the tires of F–80 aircraft, caused by a seal coat that was constructed last year by the city of Madison, Wis. Air Corps personnel also feel that there is a possibility that the motors of the jets are being damaged by dust and sand from the seal coat. The seal coat has been swept with a power broom and blown off with water and air at 90 pounds per square inch pressure. After this treatment, sand and dust are still loosened with each landing of a plane. Landings per tire have ranged from 3 to 6. Thirteen F–80 jets arrived at the field on April 10, 1951. The fuel used is JP–3.

3. The seal coat applied to the 8-year-old pavement consisted of 0.267 gallons per square yard of RC–3 and 17 pounds per square yard of cover aggregate. The cover aggregate was to have complied with the following grading and appears to be at the coarse limit.

Sieve size:	*Percent passing*
¼ inch	100
No. 4	70–100
No. 10	10–50
No. 40	0–5
No. 100	0–1

4. There is evidence of distress, resulting in cracking and rutting of the pavement on the old apron and taxiway B. These are old bituminous road mix pavements built by the city of Madison under a WPA project during the period 1936–38. These old pavements were constructed on top of a layer of black peat topsoil, averaging about 1 foot in thickness, and had started to show distress at the time of the airfield pavement evaluation in 1944.

5. It is planned to resurface the north-south and northwest-southeast runways with a 1-inch thickness of hot-plant mixed asphaltic surfacing which will not be sealed. A request has been made to the Eastern Air Defense Force for an allotment of $90,000 and work will start shortly after the receipt of the allotment.

JOHN R. HARDIN,
Colonel, Corps of Engineers, Division Engineer.

ss: D. E., Milwaukee District.

APRIL 18, 1951.

ENGER.

Subject: Inspection of bituminous pavements, Truax Airfield, Madison, Wis.
To: Division Engineer, Great Lakes Division, Corps of Engineers, United States Army, Chicago, Ill.

1. It has been reported to this office by Lieutenant Mianecke, Truax Airfield, air installations officer that the bituminous pavements on the subject airfield have been seriously damaged by blast and spillages of jet fuel from the operation of F–80 aircraft.

2. It is requested that an inspection be made of the bituminous pavements on the subject airfield.

3. It is also requested that an inspection report be submitted to this office. The report should include the items noted below:

(*a*) Type of pavements (whether hot mix or cold mix and type bituminous material used).

(*b*) Age of pavements.

(*c*) Description of damage, from either jet-fuel spillages or blast, based on visual inspection.

(*d*) Present condition of damaged pavements.

(*e*) Condition of pavement prior to start of jet aircraft operation.

(*f*) Number and type of jet aircraft which have operated on the field and length of time the jet aircraft groups have been operating on the field.

(*g*) Any information available as to density, bitumen content, gradations, or other data on the bituminous pavements.

(*h*) Type of jet fuel in use.

(*i*) Other information considered to be pertinent.

4. Experience indicates that a bituminous pavement which contains cracks permits the jet fuel to seep into the pavements and soften the bituminous material sufficiently for subsequent blasts of jet aircraft to blow out portions of the pavement.

5. The airfield pavements consisting of well designed and well constructed asphaltic concrete which have been inspected to date have not shown any material damage from spillages of jet fuel or blast of current type jet aircraft.

6. Consideration is to be given to paragraphs 4 and 5 during the inspection.

7. Recommendations are invited as to desirability of making an analysis of the pavements.

By order of the Chief of Engineers:

F. S. POORMAN,
Deputy Chief, Engineering Division, Military Construction.

[First endorsement]

SADBP—686.61 Hunter Air Force Base (April 23, 1951), 686.61 Jax Airfield.
Subject: Inspection of pavements, Hunter Airfield, Savannah, Ga., and Jacksonville Airfield, Jacksonville, Fla.
From: Office, Division Engineer, South Atlantic Division, Atlanta, Ga., April 25, 1951.
To: Chief of Engineers, Department of the Army, Washington 25, D. C.
(Attention: Enger)

1. Reference is made to letter from your office dated March 16, 1951, subject as above.

2. The basic communication indicates that Hunter Air Force Base pavements have not been damaged by jet aircraft operation.

For the division engineer:

GEORGE H. MITTENDORF,
Acting Chief, Engineering Division.

WAR DEPARTMENT,
UNITED STATES ENGINEER OFFICE,
Savannah, Ga., April 23, 1951.

SASFP 686.61 Hunter Air Force Base
Subject: Inspection of Pavements, Hunter Airfield, Savannah, Ga., and Jacksonville Airfield, Jacksonville, Fla.
To: Division Engineer, South Atlantic Division, Atlanta 1, Ga.

1. Reference is made to letter dated March 20, 1951, subject same as above, from the South Atlantic Division office to the Savannah district office, relative to inspection of pavements subjected to jet aircraft at Hunter Air Force Base, Savannah, Ga.

2. In compliance with the above-referenced correspondence, an inspection of pavements at Hunter Air Force Base was made April 13, 1951, by a representative of this Office and Air Installation Office of that base.

3. Visual inspection of flexible and concrete pavements did not reveal any signs of damage that could be attributed to jet aircraft operation. It is pointed out at this time that operation of jet aircraft at Hunter Air Force Base was limited to the Air National Guard, and also, that maintenance and repairs to jet aircraft were usually conducted on concrete aprons. The extent of possible damage to concrete joint sealing material by jet spillage could not be determined in view of the fact that all joints in the concrete aprons were resealed by the Air Force in the early summer of 1950, about the time Air National Guard was transferred from this base.

For the district engineer:

JAMES B. EDGERTON,
Assistant Chief Engineering Division.

JANUARY 23, 1953.

Enger.
Subject: Inspection of new asphaltic concrete pavements subjected to jet aircraft operation.
To: The Chief of Staff, United States Air Force
(Attention: Director of Installation, DCS/O.)

Transmitted for your information and retention is copy of letter, with enclosure, to this office from the South Atlantic Division Engineer, subject: Airfield pavement inspection dated January 13, 1953.

For the Chief of Engineers:

H. B. ZACHRISON,
Chief, Engineering Division, Military Construction.

1 Encl., Cy ltr dtd Jan 13, 53.

JANUARY 13, 1953.

SADBP 600.17 (Reed).
Subject: Airfield pavement inspection.
To: Chief of Engineers, Department of the Army, Washington 25, D. C.
(ATTN: ENGER.)

1. Report of inspection of airfields in the South Atlantic Division subjected to operation of jet aircraft is forwarded as requested in first endorsement from your Office, dated December 23, 1952, subject as above.

2. The USAFIR, South Atlantic Division, has been furnished a copy of the report.

For the division engineer:

C. P. LINDER,
Chief, Engineering Division.

1 encl., Report (dup).

JANUARY 13, 1953.

SADBP 600.17 (Reed).
Memorandum for: Chief, Engineering Division, South Atlantic Division.
Subject: Inspection of new asphaltic concrete pavements subjected to jet aircraft operation—South Atlantic Division.

1. Purpose

On invitation of the USAFIR an inspection was made January 7–8, 1953, of recently constructed asphaltic concrete pavements in the South Atlantic Division that have been subjected to extensive jet aircraft operation. The following personnel were present during the course of inspections:

Col. Paul C. Brown, Air Force Reserve, South Atlantic Division (part time)
Lt. Col. A. H. Hogan, office Air Force Reserve, South Atlantic Division (part time)
Mr. M. L. McAlpin, office Air Force Reserve, South Atlantic Division
Lt. Col. R. L. Clifford, Headquarters United States Air Force
Lt. Col. J. L. Albert, Headquarters United States Air Force
Mr. W. F. Winters, chief engineer, Asphalt Institute
Mr. W. H. Mills, Asphalt Institute
Mr. R. O. Harris, Jr., Mobile District
Mr. B. H. Cunningham, Savannah District
Mr. C. P. Coker, Jacksonville District
Mr. C. P. McCleskey, South Atlantic Division

2. Observations

(*a*) *Turner Air Force Base.*—(1) During 1951 the existing northeast-southwest runway was reinforced and extended to 10,000-foot length together with connecting taxiways, all of which were constructed with asphaltic concrete surface courses. Because of certain isolated open-textured areas in the pavement, a sand seal coat was applied during the spring of 1952. All existing aprons were constructed of cement concrete pavement in 1941.

(2) The pavements have been subjected to jet aircraft operation since December 1951. At the present time approxmately 150 F–84 type aircraft are operating on the base.

(3) Numerous discolorations are to be noted in warmup areas and on runway ends caused by fuel spillage. Three patches have been made in the pavement necessitated by displacement of pavement in soft spots, each of which approximate 1 square yard.

(4) Two systematical burned areas aprpoximately 4 feet by 18 feet by ½ inch depth, 30 cubic centimeters, were noted near the southwest end of the primary runway apparently caused by a single warmup operation of a visiting B–45 type aircraft.

(5) No additional repair to pavements is necessary at this time.

(6) Considerable erosion of earth shoulders has occurred adjacent to taxiway warmup areas and runway ends due to blast action.

(*b*) *Moody Air Force Base.*—(1) Surfacing of the extensions to the easterly and westerly north-south runways and connecting taxiways was completed in August 1952. The existing runways in use are of bituminous concrete construction and have been resealed in the recent construction program. The new bituminous concrete construction was not sealed. The existing aprons in use are of cement concrete construction.

(2) The new pavements have been in use since August 1952, and are presently being subjected to operation of approximately 140 T–33 type aircraft and 25 B–25 type aircraft. Cycles of operation approximate 20,000 to 30,000 monthly.

(3) Considerable discoloration caused by fuel spillage is to be noted around runway ends and warmup areas; however, only one small 3 feet by 3 feet by one-half inch depth soft area was noted with no displacement of the pavement.

(4) No repair of damage caused by spillage or blast has been made and none is necessary as of this date. The AIO has a project at hand for placement of a jet fuel protective membrane surfacing on all existing taxiways to prevent damage due to any expected fuel spillage. Justification for such a project is not apparent.

(*c*) *Pinecastle Air Force Base.*—(1) Pavements in use consist of a 10,000-foot-length concrete runway extended to 12,000 feet with concrete, and asphaltic concrete parallel taxiway and approximately 400,000 square yards of asphaltic concrete apron. The new pavements were completed in January 1952 and activated by jet aircraft in April 1952. There are presently assigned to the base 100 T–33, F–80, and F–84 type aircraft and 8 B–47's operating approximately 250 cycles per day.

(2) No damage has been caused to runway or taxiway except for considerable fuel spillage on the warmup pad at the south end of the runway near the hold point. None of the spillage areas are soft or show any signs of displacement.

The northerly two-thirds of the apron comprising the transient aircraft area and maintenance and parking area for F–84 type aircraft shows little deterioration since June 1952 when some slight deterioration existed from fuel-tank overflow caused by expansion of fuel.

The southerly one-third of the apron used for parking and maintenance of F–80 type aircraft is rapidly deteriorating due to excessive daily spillage of fuel and solvents in an approximate 20-foot diameter maintenance area for each aircraft. Several areas were noted to be softened to the full 4-inch depth of pavement. Erosion to approximately 1½-inch depth has occurred in numerous areas and a considerable amount of loose aggregate was floating on the surface of the pavement.

Several small burned areas were noted in one section of the apron caused by outboard jets on a B–47 aircraft when base operating personnel had investigated possible damage from extended full power engine runup.

(3) No provision to prevent or remove fuel and oil spillage was to be noted. No repair of apron pavement has been accomplished to date although a considerable amount of repair is necessary at this time.

(*d*) *MacDill Air Force Base.*—(1) Pavements presently in use consist of aprons A, B, D, and E (515,000 squars yards) reinforced with 4-inch to 6-inch asphaltic concrete overlay completed in July 1952, apron C surfaced with tar concrete 1945 and resealed April 1952, and approximately 150,000 square yards of new asphaltic concrete apron completed August 1952. Two runways with necessary connecting taxiways constructed of asphaltic concrete consist of the 10,000-foot instrument runway with 300-foot concrete ends constructed in 1943 and the 7,000-foot northwest/southeast runway constructed in 1946. Both runways were sealed when constructed. The instrument runway was resealed by the AIO in about 1950 using an oversize slag aggregate and the 2,000-foot end sections later resealed in 1952 to reduce abrasive surface texture for B–47 landing operations.

(2) The new pavements have been subjected to B–47-type aircraft operations since April 1952. The field is presently used by some 75 B–47's and also F–80's, C–97's, and B–50-type aircraft.

(3) The apron overlay pavements were subjected to immediate use by above aircraft on completion of the individual sections of pavement.

Throughout the approximately 665,000 square yards of new apron pavement surfaces only a few scuffed areas are to be noted and these occurred in the early life of the pavement.

In the maintenance area for F–80-type aircraft some very slight deterioration has been caused by spillage on construction joints. The main pavement area has not been affected.

An excellent housekeeping job is being done at this base. No repairs to the bituminous apron have been accomplished to date and none is required at this time.

The joint-sealing material in the concrete ends of the instrument runway has been badly damaged due to jet blast in warm-up. The seal coat has been damaged on bituminuos pavement adjacent to runway ends where runup was not

made on the concrete. The seal coat damage has been confined to a distance within 150 feet of the concrete end.

Excessive damage has occurred on the old asphaltic concrete warmup pad at the southern end of the northwest-southeast runway due to the jet blast under extended maintenance full-power runup operations of the outboard jets of B–47 aircraft.

(4) Other observations of conditions at this base not attributable to blast or fuel spillage from jet aircraft reveal that the concrete inlet grates within the apron area are rapidly deteriorating and that the center portions of primary taxiways are consolidating under B–47-type aircraft landing gear.

G. C. REED, Jr.

SUPPLEMENTARY STATEMENT IN BEHALF OF PORTLAND CEMENT ASSOCIATION

As suggested by the chairman of the committee and Special Counsel John J. Courtney, this supplementary statement on concrete airfield pavement has been prepared for the record. This statement contains information to supplement the statement presented February 5 and to further answer some of the questions of the hearings on February 5.

Concrete is needed for all airfield areas, critical and noncritical. In addition to the reasons of visibility, skid resistance, low crown and stopping distance, rigid surface and freedom from loose particles, the following points should be given emphasis. New and future planes will have higher speeds in both landing and takeoff requiring even, uniform surfaces throughout the length of the runway. The thrust of aircraft engines is constantly increasing, thus causing higher temperatures and increased blast velocity. Even during taxiing and takeoffs these future aircraft will require concrete to withstand the blast and heat of jet and rocket exhausts. At the location of intersecting taxiways, aircraft must slow down on the runway in order to turn onto the taxiways. The runway at these locations requires concrete to withstand the increased heat and fuel spillage which result from lower speeds at these locations. As evidence of the importance of advanced design, Time and Newsweek dated February 8, 1954, both give pictorial and news coverage of current trends.

Ample testimony on the future performance of jets, blast temperature, velocity, and angle of impingement were presented at the Port Hueneme Symposium of Jets in April 1952. The following quotations from representatives of two aircraft manufacturers at that meeting are presented for your information:

Fred R. Payne, Jr., North American Aviation, Inc., on future trends in aircraft:

"As a quantitative estimate, present jet velocities and temperatures are in the region of 1,500 feet per second and 1,300° F. Future velocities and temperatures of afterburning turbojets and rockets will be in the order of 2,000 to 8,000 feet per second and 3,500° to 5,000° F."

E. A. Rock, Boeing Airplane Co.:

"Research should be conducted with the view in mind of supplying to the aircraft designer, pavements to withstand stoichiometric temperatures, with exhaust velocities consistent with jet-engine development, angles of inclination of 0° to 20°, and tailpipe elevations of 1 foot and up."

MAINTENANCE COSTS

Maintenance cost on concrete pavement are less than those on bituminous pavement. As proof of that fact, we have submitted to the members of the committee a publication (Road Surface Maintenance Costs From 28 States) and are submitting now as attachment No. 1 its condensation (With Portland Cement Concrete Road Surface Maintenance Costs Are Less). This information, which summarizes the individual records of the State highway departments, shows costs for an average period of service of 20.8 years.

The price per mile as summarized in these booklets shows portland cement concrete to cost $140.61 and bituminous concrete on a flexible base to cost $208.45. Converted to a price in dollars per square yard per year, which would be more applicable to airfield pavements, this becomes $0.012 for concrete and $0.018 for bituminous pavement.

These costs cover only routine surface maintenance costs, those performed by maintenance crews operating daily over the section. They do not include periodic costs performed by special crews, such as seal coating. This work is not necessary on concrete but is essential for preserving the surface of bituminous materials.

It is difficult to obtain similar maintenance figures for airfield pavements. It seems logical, however, that the highway maintentance figures given above will be closely duplicated on airfield pavements as the years of service increase in the same proportion so that maintenance due to weather and surface wear are brought into the picture. Since highway pavements are not subjected to fuel spillage and blast from jet engines, it seems reasonable to expect an even greater differential between maintenance costs on airfields than on highways.

SERVICE LIFE

To show the service life of concrete pavements for military airfields we have assembled the attached tabulation of data (attachment No. 2). These data show the amount of concrete pavement at some 103 Air Force bases. They also show that 73.3 percent of this total yardage has been in service since 1945 (9 years or more in age).

A summary of this tabulation is presented here to give some idea of the age of concrete pavements now serving Air Force operations:

Area of pavement constructed prior

Year:	*Square yards*
1939	339,000
1940	80,000
1941	7,271,000
1942	9,361,000
1943	20,279,000
1944	9,446,000
1945	11,648,000

From Air Force testimony it would appear that jets may operate from all curcent bases. To our knowledge there are no bases in the United States that do not have some concrete.

SKID RESISTANCE

On the subject of skid resistance and stopping distances, we furnish the committee with the results of actual tests. Information has been gathered to illustrate the superior skid-resistant qualities of concrete. The data were gathered from published reports on skid-resistance tests performed by recognized authorities on skid resistance. The information is presented and identified in the attached charts (attachment No. 3). The results of the tests have shown that concrete retains its uniformly high skid resistance throughout a wide range in ages and surface textures of the pavements.

The attached comparisons of skid-resistant qualities are limited to portland cement concrete pavement and dense-graded, hot-mix, hot-laid asphalt. This type of asphalt pavement is the type recommended for use on heavy-duty airfields by the Asphalt Institute in testimony before this committee on February 3, 1954.

The following quotation concerns skid-resistant qualities and was made by a recognized authority on skid resistance as a result of tests and studies on the subject (R. A. Moyer, 34th Annual Convention, American Road Builders' Association, January 11–15, 1937, p. 6, par. 4): "The portland cement concrete surfaces provide the largest mileage of a uniform standard of construction among all the high-type surfaces used in this country today. The skidding properties of portland cement concrete were found to be the most consistent of all the surfaces on which tests were run."

EFFECT OF AFTERBURNERS

During the past 2 years the addition of afterburners has further increased heat and velocity of exhaust blast. Afterburners which increase the performance of jet aircraft are used at times when additional power is required, particularly during takeoffs. The addition of an afterburner to a jet engine doubles the velocity and temperature of the exhaust blast. The impact of afterburner operations on pavement surfaces is just beginning to have effect as operations increase at our military airfields. This is further indication that we are just in the dawn of the jet age. Concrete pavement has not been damaged by jets with afterburners at bases where they are now operating.

EFFECT OF RATO AND JATO

Many take offs using both RATO and JATO units have been made by aircraft at Edwards Air Force Base, Calif. and the Patuxent Naval Air Station in Maryland. An inspection of the concrete pavement at these two airfields shows that concrete has not been affected by these operations.

DESIGN OF CONCRETE COMPARED TO THE DESIGN OF FLEXIBLE PAVEMENTS

During the hearings the question of load carrying abilities of pavement types was discussed. Experience and loading tests have shown that designs for concrete will remain adequate for the life of the pavement. Changes in supporting power due to increase in moisture and frost do not affect the load carrying capacity of pavement. As a matter of fact, concrete pavements gain in strength with age from the time they are placed. This is taken into account in making pavement evaluation surveys by the Corps of Engineers.

Flexible pavements may lose supporting power through loss in stability of the granular base courses as a result of increased moisture and freeze and thaw cycles. Actual tests on flexible pavements have also shown loss in stability due to compaction under traffic. (See Reduction in Soil Strength With Increase in Density, by Charles R. Foster, ASCE proceedings, separate No. 228, vol. 79, July 1953.) Loading tests conducted by the Corps of Engineers at their flexible pavement laboratory in Vicksburg, Miss., show that their present pavement design curves for flexible thicknesses are slightly on the unsafe side. (See Waterways Experiment Station, U. S. Engineers, Technical Memorandum No. 3-349, Design of Flexible Airfield Pavement for Multiple-Wheel Landing Gear Assemblies, September 1952, conclusion, p. 31.)

THE ECONOMY OF CONCRETE PAVEMENT

First cost.—As stated in our presentation, the first cost of concrete pavements varies from project to project, depending on location, thickness, size of project, and many other factors. Concrete pavement costs have been going down because of improvement in equipment and keener competition among paving contractors. All materials required for pavement construction are freely available and can be purchased on the competitive open market by any contractor.

Below are average cubic yard prices which were obtained from many projects throughout the country during the past 3 years:

Tabulation of weighted-average costs of airfield pavements for 1951, 1952, and 1953

1. Cost per cubic yard:

Year	Square yards	Weighted average
1951	4,157,330	$17.57
1952	3,475,845	14.94
1953	6,515,627	14.97
Average		15.72

2. Cost per square yard:

Thickness:	*Cost per square yard*	Thickness—Continued	*Cost per square yard*
6 inches	$3.13	14 inches	$5.31
7 inches	3.67	15 inches	6.43
8 inches	3.76	16 inches	6.55
9 inches	4.63	17 inches	7.28
10 inches	4.64	18 inches	6.70
11 inches	5.25	19 inches	7.75
12 inches	5.77	20 inches	7.10
13 inches	6.17		

Group 1 prices are based on the average cost of the cubic yard price for the concrete pavement in place. Square yard prices are also shown in group 2 for varying pavement thickness.

In weighing first cost, the total bid price on the project is the price to be studied in comparing alternate bids on two pavement types. Unit prices for pavement alone do not give the true facts. Even though the unit prices for the bituminous-type pavement may be less per square yard, many other factors add to the total bituminous bid price. For instance, the quantity of excavation will be much larger because of the difference in pavement thickness and the amount of grading involved; also, drainage lines and structures will cost more for bituminous pavements than for concrete since they must be set deeper in order to clear the thicker bituminous pavements.

Published bids submitted by contractors on Air Force and Navy projects during the past 3 years show that there is keen competition for concrete paving projects.

ECONOMIC STUDIES

In order to make a true comparison of pavement costs between concrete and other types, it is necessary to conduct an economic study to determine the lowest annual cost of pavement. In making such a study, the engineer should consider construction cost, maintenance cost, periodic resurfacings, the total life of the pavement and the salvage value which can be assigned to the pavement.

The average life figures which are available for highways show concrete pavement to have an average life of 28.2 years and bituminous pavement an average life of 13.5 years. These figures, which were obtained by the Bureau of Public Roads in a nationwide study of some 50,000 miles of pavement, were obtained from the Highway Research Board Proceedings, vol. 28, 1948. Most airfield pavements have not yet been in service long enough to determine the probable total life.

Attachment No. 4 is a typical economic study for airfield projects which has been prepared to show the proper method in obtaining annual costs of pavement. This is a technique commonly used in highway paving practice. Future developments in jetplane operation will make the economic advantages of concrete even more pronounced. The construction cost, or first cost, used in this study indicates an extreme difference in first cost of 67 percent. This value was selected to show that even with the 60 percent differential suggested by the chairman, concrete has a lower annual cost. Using the 5 percent differential set by the Air Force, the savings by use of concrete would be much larger. The annual cost is the only true method for comparing two pavement types.

JOINT SEALING MATERIAL DAMAGE BY JET BLASTS

Several papers presented at the Port Hueneme Symposium on Airfield Pavements for Jet Aircraft described the effect of jet blasts and fuel spillage on joint sealing materials in common use at that time.

SYMPOSIUM ON AIRFIELD PAVEMENTS FOR JET AIRCRAFT (ATTACHMENT NO. 5)

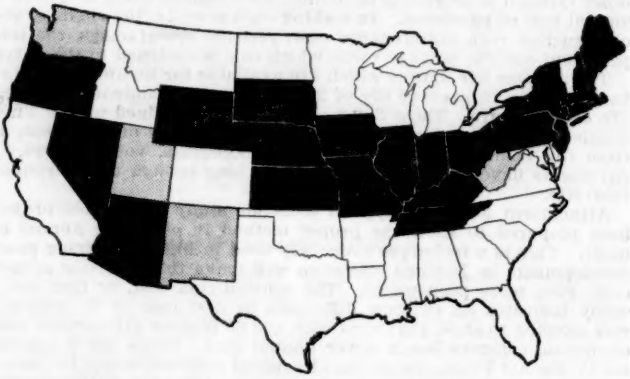
In this supplementary statement, as well as in testimony by representatives of several governmental agencies, frequent reference has been made to proceedings of the Symposium on Airfield Pavements for Jet Aircraft sponsored by the United States Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme, Calif., April 17 and 18, 1952. The proceedings of that symposium summarize information gained from experience as of that date by aircraft manufacturers and military and civilian aviation authorities directly concerned with the design, construction, and maintenance of airfield pavements for the successful operation of modern jet aircraft. They also include information on trends in jet aircraft design which will affect seriously airfield pavement requirements of the future.

It is respectfully requested that the Subcommittee on Defense Activities make all of the proceedings of this symposium an integral part of the transcript of the hearings. No other single publication contains as much information on the subject of suitability of pavement types for jetplane operation.

Attachment No. 1

WITH PORTLAND CEMENT CONCRETE road surface maintenance costs are *LESS*

Official records from the states shown in black are the basis for this summary of surface maintenance costs. The four shaded states have not published recent cost data.



CONTINUING PROOF OF CONCRETE'S LOW-ANNUAL-COST

Long life and low maintenance costs mean low - annual - cost. Over long periods of years, concrete continues to give lower surface maintenance costs than any other surface type -- based on an average maintenance period of 20.8 years and covering over 200,000 miles of highways. Official records of 24 states show . . . . . .

THE COST OF MAINTAINING

PORTLAND CEMENT CONCRETE PAVEMENT IS

29.1% TO 61.5% LESS

THAN ANY OTHER TYPE

HERE ARE THE FACTS.....

There are 28 state highway departments which have published road maintenance costs in sufficient detail so that costs of maintaining the surface could be segregated. However, in four of the states (New Mexico, Utah, Washington and West Virginia), such costs have not been published since before World War II because of lack of personnel. The remaining 24 states have kept their records up to date. Years covered and detailed costs, summarized from official records, are given in the table on the last page of this folder. The study covers 200,005.2 miles of highway of which 50,524.9 are portland cement concrete pavement.

It should be emphasized that data for all years published by each state have been summarized for the table. There have been no deletions or omissions and all figures used are as reported by the states. No attempt has been made to adjust for the fluctuating value of the dollar.

CONCRETE COSTS LESS TO MAINTAIN

In considering surface maintenance costs, one should bear in mind that the average traffic volume on concrete is heavy--frequently several times as heavy, both in number of vehicles and in number of heavy wheel-loads carried daily, as the traffic on some of the other surface types. Should these low-traffic-volume roads carry the same number of vehicles as concrete, even for a short period, the surface maintenance costs unquestionably would be increased.

Average surface maintenance costs from all 28 states and, in particular, the 24 states with recent cost data, demonstrate the fact that portland cement concrete pavement costs much less to maintain than does any of the other types included in the study. The table below lists the average surface maintenance costs per mile per year on all major types built on state primary highways.

SURFACE TYPE	ANNUAL MAINTENANCE COST PER MILE
Portland Cement Concrete	$140.80
Bituminous Concrete -- rigid base	198.60
Bituminous Concrete -- rigid and flexible base	207.86
Bituminous Concrete -- flexible base	209.84
Mixed Bituminous, road or plant mixes	301.87
Bituminous Macadam	345.48
Gravel or Stone	352.32
Bituminous Surface-Treated	365.33

This table shows that the annual cost of maintaining concrete is 29.1 per cent less than the next type and 61.5 per cent less than the cost of maintaining bituminous surface-treated roads, the last type in the table.

The above costs are from records covering an average period of 20.8 years. They deserve your thoughtful consideration.

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DOLLARS NEEDED TO MAINTAIN ONE MILE OF ROAD SURFACE ONE YEAR*
Based on average surface maintenance costs from 24 states over a period of service averaging 20.8 years. Figures collected from all states releasing detailed surface maintenance costs.
PORTLAND CEMENT CONCRETE
BITUMINOUS CONCRETE -- RIGID BASE
BITUMINOUS CONCRETE -- RIGID AND FLEXIBLE BASE
BITUMINOUS CONCRETE -- FLEXIBLE BASE
MIXED BITUMINOUS -- ROAD OR PLANT MIXES
BITUMINOUS MACADAM
GRAVEL OR STONE
BITUMINOUS SURFACE - TREATED
* EACH SYMBOL REPRESENTS $50

AVER

STATE	NUMBER OF YEARS COVERED BY STATE RECORDS	P
ARIZONA	18	
CONNECTICUT	9	
FLORIDA	24	
ILLINOIS	30	1
INDIANA	23-9/12	
IOWA	23	
KANSAS	21	
KENTUCKY	12	
MAINE	15	
MASSACHUSETTS(1)	21	
MISSOURI	22	
NEBRASKA	21	
NEVADA	23-7/12	
NEW HAMPSHIRE	17	
NEW JERSEY	24	
NEW YORK	28	
OHIO	25-6/12	
OREGON	28	
PENNSYLVANIA	8	
RHODE ISLAND(1)	29	
SOUTH DAKOTA	22	
TENNESSEE	14	
TEXAS	22	
WYOMING	19	
Total miles in service		
Average surface maintenance costs per mile per year		
NEW MEXICO	5	
UTAH	12	
WASHINGTON	19	
WEST VIRGINIA	11	
Total miles – 4 states not reporting costs since start of World War II		
Average surface maintenance cost for 4 states per mile		
GRAND TOTAL, MILES		
Average cost per mile		

NOTES: The above table covers 215,41 concrete. In addition, there are cost of $297.19 per mile per y miles are Class G on rigid base

(1) Costs are reported on a sq. y

(2) Although practically all pa included in computing averag

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AVERAGE SURFACE MAINTENANCE COSTS — 28 STATE PRIMARY HIGHWAY SYSTEMS

Items such as traffic service, snow removal, weed cutting, etc. not included.

BER EARS ERED TATE ORDS	PORTLAND CEMENT CONCRETE U.S.B.P.R. Class J		BITUMINOUS CONCRETE RIGID BASE U.S.B.P.R. Class I		BITUMINOUS CONCRETE RIGID AND FLEX. BASE U.S.B.P.R. Class I		BITUMINOUS CONCRETE FLEXIBLE BASE U.S.B.P.R. Class I		MIXED BITUMINOUS SURFACES U.S.B.P.R. Class G		BITUMINOUS MACADAM U.S.B.P.R. Class H		GRAVEL OR STONE U.S.B.P.R. Class E		BITUMINOUS SURFACE-TREATED U.S.B.P.R. Class F	
	Miles in service in last maint. period	Weighted aver. maint. cost per mile per year	Miles in service in last maint. period	Weighted aver. maint. cost per mile per year	Miles in service in last maint. period	Weighted aver. maint. cost per mile per year	Miles in service in last maint. period	Weighted aver. maint. cost per mile per year	Miles in service in last maint. period	Weighted aver. maint. cost per mile per year	Miles in service in last maint. period	Weighted aver. maint. cost per mile per year	Miles in service in last maint. period	Weighted aver. maint. cost per mile per year	Miles in service in last maint. period	Weighted aver. maint. cost per mile per year
	110.1	$170.56	–	$ –	–	$ –	24.4	$132.84	554.0	$256.05	–	$ –	216.3	$272.18	2,530.0	$235.05
	1,132.0	187.76	127.0	436.87	–	–	–	–	1,257.0	240.89	274.0	227.05	–	–	425.0	441.40
	540.3	59.46	–	–	907.1	32.81	–	–	2,793.2	70.22	–	–	–	–	4,779.8	102.43
	12,037.3	128.33	1,297.8	98.51	–	–	–	–	–	–	21.5	195.97	179.3	162.63	463.9	148.28
/12	2,381.0	92.42	–	–	1,360.1	90.83	–	–	2,678.9	503.35	18.3	273.68	98.9	620.53	75.7	524.22
	6,234.6	107.81	–	–	–	–	–	–	–	–	–	–	2,081.2	359.82	1,007.8	672.55
	1,194.3	157.55	–	–	327.4	126.49	–	–	2,141.3	418.32	75.3	241.80	1,227.5	317.59	4,031.4	542.99
	1,128.7	212.37	342.3	219.87	–	–	1,383.9	149.41	4,995.9	302.18	–	–	3,754.9	433.70	1,062.4	417.29
	160.8	143.40	–	–	–	–	138.1	153.79	201.8	283.83	452.1	202.09	1,094.4	178.11	7,264.6	398.53
	503.9	118.90	–	–	–	–	458.4	105.53	–	–	1,396.1	121.77	–	–	28.1	450.77
	3,754.1	163.73	–	–	–	–	–	–	3,582.1	473.49	667.5	255.05	325.6	280.27	–	–
	1,264.6	104.17	50.4	229.20	–	–	–	–	–	–	–	–	5,011.6	301.11	2,879.5	274.13
/12	1.0[2]	103.70	–	–	–	–	–	–	3,211.1	76.35	–	–	354.0	174.64	–	–
	255.5	192.27	–	–	–	–	57.9	212.31	–	–	253.1	181.96	120.4	197.77	3,040.0	387.84
	1,438.4	241.92	166.0	565.17	–	–	85.8	907.23	–	–	17.3	1,787.24	–	–	63.1	1,218.16
	4,941.4	166.46	78.9	308.85	–	–	35.4	495.08	2,354.5	269.13	1,537.2	468.06	530.1	667.58	12.5	418.17
/12	1,735.4	192.63	–	–	3,768.3	264.76	–	–	7,262.2	455.78	384.8	317.97	1,532.5	477.69	1,477.3	525.36
	336.0	190.97	–	–	–	–	584.0	336.60	–	–	1,294.0	419.93	206.0	346.67	2,396.0	567.05
	4,410.9	206.22	1,744.3	144.67[3]	–	–	4,188.0	158.40[3]	1,895.2	144.25[3]	–	–	77.5	109.02	–	–
	262.7	65.73	70.4	140.69	–	–	80.5	260.89	–	–	327.9	79.56	–	–	–	–
	400.5	71.41	–	–	–	–	–	–	3,106.5	413.38	–	–	2,637.7	260.41	–	–
	1,598.7	137.08	272.6	97.86	–	–	294.5	124.39	–	–	152.0	108.20	596.8	302.46	2,548.5	308.00
	4,701.7	102.47	1,220.9	199.68	–	–	4,380.5	173.63	24,152.9	220.79	–	–	247.4	308.72	–	–
	1.0[2]	125.24	–	–	–	–	–	–	4,600.0	155.89[4]	–	–	–	–	–	–
	50,524.9		5,370.6		6,362.9		11,711.4		64,786.6		6,871.1		20,292.1		34,085.6	
	$140.80		$198.60		$207.86		$209.84		$301.87		$345.48		$352.32		$365.33	
	53.4	68.45	–	–	–	–	392.6	102.97	2,307.6	184.32	1,063.0	113.25	–	–	609.4	140.28
	325.0	100.95	–	–	–	–	131.9	106.02	–	–	1,320.7	198.31	5.0	186.29	1,247.6	125.26
	1,096.2	125.04	–	–	–	–	24.8	232.88	–	–	254.4	316.47	–	–	2,277.2	216.81
	1,045.1	156.45	–	–	–	–	446.1	238.54	–	–	436.6	151.98	665.9	265.12	1,709.3	286.87
	2,519.7						995.4		2,307.6		3,074.7		670.9		5,843.5	
	$133.05		–		–		$180.75		$184.32		$247.67		$264.76		$220.88	
	53,044.6		5,370.6		6,362.9		12,706.8		67,094.2		23,366.8		7,542.0		39,929.1	
	$140.61		**$198.60**		**$207.86**		**$208.45**		**$299.69**		**$344.27**		**$342.29**		**$356.57**	

s 215,417.0 miles of road in the 28 states, of which 53,044.6 miles are portland cement here are on state primary systems 997.1 miles of brick with an average surface maintenance le per year, and 2,311.9 miles of miscellaneous types not commonly built; of this 2,109.3 id base in New York.

n a sq. yd. basis; mileage figures are for an equivalent mile of 20-ft. surface.

y all pavement of this type has been retired from service, surface maintenance costs are g averages.

(3) To this average should be added $250 per mile per year for surface treatment costs on Class I surfaces and $200 per mile per year for such costs on Class G surfaces. These periodic costs are not included in the routine maintenance costs.

(4) Does not include periodic maintenance such as surface treatments, patching, etc. In 1951, these cost $804,350.04 or $174.86 per mile.

PORTLAND CEMENT ASSOCIATION • 33 WEST GRAND AVENUE, CHICAGO 10, ILLINOIS

activities of the Portland Cement Association, a national organization, are limited to scientific research, the development of new or improved products and methods, technical ce, promotion and educational effort (including safety work), and are primarily designed to improve and extend the uses of portland cement and concrete. The manifold program e Association and its varied services to cement users are made possible by the financial support of over 65 member companies in the United States and Canada, engaged in manufacture and sale of a very large proportion of all portland cement used in these two countries. A current list of member companies will be furnished on request.

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ATTACHMENT No. 2

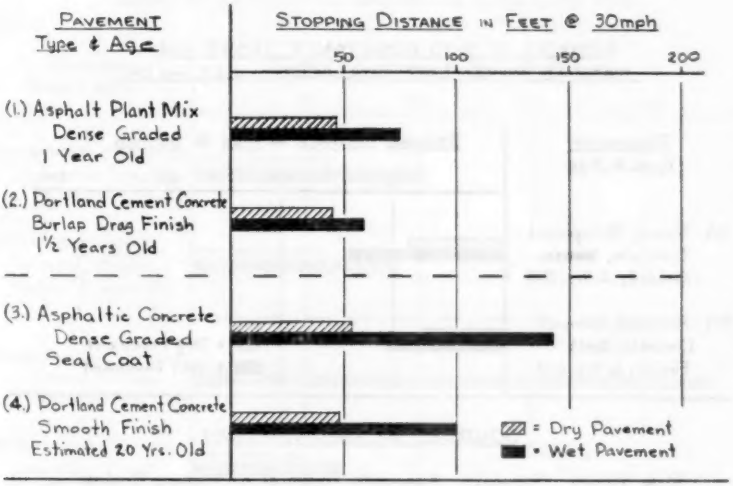
Airfield and location	Total area of concrete pavement (square yards)	Area of concrete pavement constructed prior to—	
		Square yards	Year
Alexandria Air Force Base, La	964,000	886,000	1943
Harlinden Air Force Base, Tex	1,019,000	861,000	1945
Altus Air Force Base, Okla	253,000	253,000	1943
Amarillo Air Force Base, Tex	283,000	259,000	1943
Andrews Air Force Base, Md	1,148,000	1,076,000	1944
Atterbury Air Force Base, Ind	435,000	424,000	1943
Barksdale Air Force Base, La	2,223,000	1,813,000	1945
Bergstrom Air Force Base, Tex	311,000	302,000	1944
Biggs Air Force Base, Tex	88,000	88,000	1945
Big Springs Air Force Base, Tex	304,000	304,000	1942
Bolling Air Force Base, D. C	259,000	255,000	1944
Brookley Air Force Base, Ala	1,254,000	938,000	1943
Campbell Air Force Base, Ky	23,000	23,000	1942
Carswell Air Force Base, Tex	2,300,000	1,717,000	1945
Chanute Air Force Base, Ill	891,000	891,000	1944
Clinton County Air Force Base, Ohio	273,000	273,000	1945
Clovis, Air Force Base, N. Mex	228,000	228,000	1942
Columbus Air Force Base, Miss	619,000	614,000	1943
Connaly Air Force Base, Tex	1,205,000	912,000	1943
Craig Air Force Base, Ala	134,000	80,000	1940
Forbes Air Force Base, Kans	1,545,000	863,000	1943
Geiger Field, Wash	817,000	801,000	1943
Ardmore Air Force Base, Okla	594,000	594,000	1943
George Air Force Base, Calif	551,000	491,000	1945
Godman Air Force Base, Ky	201,000	195,000	1943
Goodfellow Air Force Base, Tex	254,000	254,000	1943
Gore Field, Mont	178,000	170,000	1942
Grand View Air Force Base, Mo	520,000	323,000	1943
Greenville Air Force Base, Miss	765,000	630,000	1943
Grenier Air Force Base, N. H	243,000	243,000	1942
Griffis Air Force Base, N. Y	705,000	619,000	1943
Langley Air Force Base, Va	968,000	712,000	1941
Laredo Air Force Base, Tex	320,000	320,000	1945
Larson Air Force Base, Wash	1,849,000	1,528,000	1943
Lawson Air Force Base, Ga	228,000	228,000	1943
Lincoln Air Force Base, Nebr	1,359,000	819,000	1944
Lockbourne Air Force Base, Ohio	2,053,000	1,029,000	1944
Lowry Air Force Base, Colo	532,000	532,000	1941
Luke Air Force Base, Ariz	932,000	710,000	1943
MacDill Air Force Base, Fla	1,115,000	731,000	1943
March Air Force Base, Calif	1,340,000	315,000 615,000 77,000	1940 1945 1940
Mather Air Force Base, Calif	322,000	322,000	1941
Maxwell Air Force Base, Ala	1,648,000	1,648,000	1945
McChord Air Force Base, Wash	438,000	255,000	1941
McClellan Air Force Base, Calif	160,000	160,000	1941
McGhee-Tyson Air Force Base, Tenn	640,000	272,000	1944
McGuire Air Force Base, N. J	1,012,000	356,000	1945
Memphis Air Force Base, Tenn	468,000	455,000	1943
Mitchell Air Force Base, N. Y	985,000	339,000	1939
Nellis Air Force Base, Nev	399,000	194,000	1945
New Castle County Air Force Base, Del	149,000	143,000	1945
Norton Air Force Base, Calif	754,000	614,000	1942
Offutt Air Force Base, Nebr	956,000	932,000	1944
O'Hare Air Force Base, Ill	825,000	582,000	1943
Olmstead Air Force Base, Pa	260,000	260,000	1941
Oscoda Air Force Base, Mich	509,000	410,000	1942
Otis Air Force Base, Mass	255,000	240,000	1942
Paine Air Force Base, Wash	199,000	185,000	1941
Patrick Air Force Base, Fla	389,000	194,000	1942
Perrin Air Force Base, Tex	574,000	453,000	1941
Pinecastle Air Force Base, Fla	862,000	488,000	1942
Pope Air Force Base, N. C	143,000	143,000	1942
Presque Isle Air Force Base, Maine	224,000	199,000	1943
Randolph Air Force Base, Tex	1,216,000	1,080,000	1945
Reese Air Force Base, Tex	421,000	413,000	1942
Robins Air Force Base, Ga	772,000	491,000	1942
Scott Air Force Base, Ill	826,000	770,000	1943
Selfridge Air Force Base, Mich	793,000	793,000	1943
Sewart Air Force Base, Tenn	735,000	680,000	1942
Shaw Air Force Base, S. C	770,000	641,000	1942
Sheppard Air Force Base, Tex	313,000	240,000	1942
Smoky Hill Air Force Base, Kans	2,379,000	1,714,000	1942
Suffolk County Air Force Base, N. Y	646,000	306,000	1943
Tinker Air Force Base, Okla	1,683,000	1,674,000	1943
Travis Air Force Base, Ga	925,000	582,000	1942
Turner Air Force Base, Ga	413,000	413,000	1943
Tye Air Force Base, Tex	628,000	118,000	1944
Tyndall Air Force Base, Fla	1,083,000	503,000	1941
Vance Air Force Base, Okla	689,000	648,000	1943

ATTACHMENT No. 2—Continued

Airfield and location	Total area of concrete pavement (square yards)	Area of concrete pavement constructed prior to—	
		Square yards	Year
Wendover Air Force Base, Utah	356,000	356,000	1941
Westover Air Force Base, Mass	1,046,000	732,000	1944
Wichita Air Force Base, Kans	2,868,000	1,063,000	1943
Williams Air Force Base, Ariz	177,000	110,000	1943
Wright Air Force Base, Patterson, Ohio	2,200,000	751,000	1943
		368,000	1941
Gunter Air Force Base, Ala	121,000	121,000	1942
Hamilton Air Force Base, Calif	687,000	687,000	1941
Hill Air Force Base, Utah	752,000	752,000	1941
Hunter Air Force Base, Ga	1,010,000	671,000	1944
Indian Springs Air Force Base, Nev	156,000	156,000	1944
Keesler Air Force Base, Miss	272,000	213,000	1942
Kelley Air Force Base, Tex	1,100,000	822,000	1944
		79,000	1939
Kirtland Air Force Base, N. Mex	352,000	67,000	1941
Lake Charles Air Force Base, La	1,857,000	515,000	1941
Davis-Monthan Air Force Base, Ariz	811,000	428,000	1945
Donaldson Air Force Base, S. C	1,382,000	926,000	1942
Dover Air Force Base, Del	593,000	593,000	1944
Dow Air Force Base, Maine	287,000	285,000	1942
Edwards Air Force Base, Calif	1,700,000	859,000	1945
Eglin Air Force Base, Fla	768,000	752,000	1945
Ellington Air Force Base, Tex	1,035,000	1,000,000	1941
Elmendorf Air Force Base, Alaska	512,000	512,000	1941
Fairchild Air Force Base, Wash	759,000	759,000	1943
Dobbins Air Force Base, Ga	1,209,000	778,000	1944

Attachment No. 3

RESULTS OF SKID RESISTANCE TESTS ON CALIFORNIA PAVEMENT SURFACES - WET AND DRY


Pavement Type & Age
Stopping Distance in Feet @ 30mph
50
100
150
200
(1.) Asphalt Plant Mix Dense Graded 1 Year Old
(2.) Portland Cement Concrete Burlap Drag Finish 1½ Years Old
(3.) Asphaltic Concrete Dense Graded Seal Coat
(4.) Portland Cement Concrete Smooth Finish Estimated 20 Yrs. Old
= Dry Pavement
= Wet Pavement

SOURCE OF INFORMATION

R.A. Moyer, Research Engr., Inst. of Trans. & Traffic Engr., Univ. of Calif., Berkeley. "Skid Resistance of Road Surfaces - California Tests". in "Proceedings, The Fourth California Street & Highway Conference", Univ of Calif., Feb. 6-8, 1952.
Pavement (1.) = p. 73, Fig. 10 of above publication.
" (2.) = p. 75, Fig. 13 " " " .

R.A. Moyer & J.W. Shupe, Inst. of Trans. & Traffic Engr., Univ. of California, "Roughness and Skid Resistance Measurements of Pavements in California", in "Highway Research Board Bulletin No. 37, 1951".
Pavement (3.) = p. 26, Fig 30 of above publication.
" (4.) = p 27, Fig. 32 " " " .

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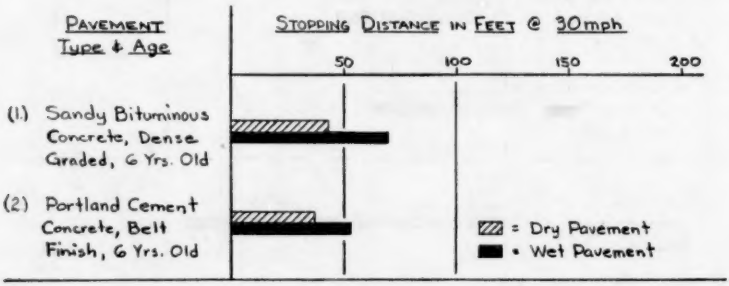
RESULTS OF SKID RESISTANCE TESTS ON KANSAS PAVEMENT SURFACES - WET AND DRY

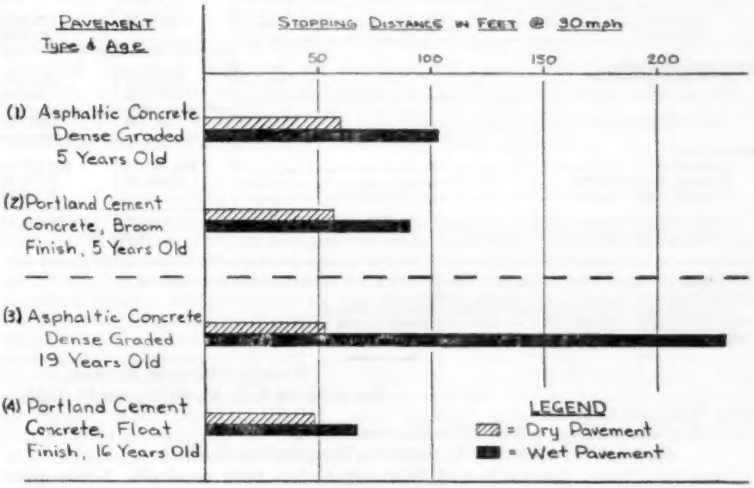


SOURCE OF INFORMATION

R. A. Moyer, Research Associate Professor of Highway Engineering, Iowa State College, Ames, Iowa, "Motor Vehicle Operating Costs, Road Roughness and Slipperiness of Various Bituminous and Portland Cement Concrete Surfaces" in "Highway Research Board Proceedings; 1942".

Pavement (1.) = Surface A_2, p. 46 of above publication.
" (2.) = Surface C_7, p. 47 " " " .

RESULTS OF SKID RESISTANCE TESTS ON OREGON PAVEMENT SURFACES - WET AND DRY


Pavement Type & Age
Stopping Distance in Feet @ 30 mph
50
100
150
200
(1) Asphaltic Concrete Dense Graded 5 Years Old
(2) Portland Cement Concrete, Broom Finish, 5 Years Old
(3) Asphaltic Concrete Dense Graded 19 Years Old
(4) Portland Cement Concrete, Float Finish, 16 Years Old
LEGEND
= Dry Pavement
= Wet Pavement

SOURCE OF INFORMATION

"Technical Report No. 39-5, Oregon State Highway Department, 'Preliminary Report on Skid-resistant Characteristics of Oregon Pavement Surfaces'" by K.M. Klein & W.J. Brown, Engineers, Traffic Engineering Division; December, 1939.

Pavement (1) = Surface A-3, pp. 14 & 64 of above publication.
" (2) = Surface C-5, pp. 12 & 63 " " " .
" (3) = Surface A-2, pp. 14 & 64 " " " .
" (4) = Surface C-2, pp. 11 & 62 " " " .

ATTACHMENT No. 4

Typical annual costs

[100,000 square yard airport pavement]

Item	Type of pavement	
	Concrete	Flexible
Basic data:		
First cost per square yard [1]	$6.55	$3.93
Salvage value, end of service life [2] ..... percent	40	40
Service life [3] ..... years	28.2	13.5
Maintenance cost per square yard:		
Routine [4]	$0.0120	$0.0178
Periodic [5]		$0.0222
Pavement cost data:		
First cost for project	$655,000	$393,000
Salvage value	262,000	157,200
Total depreciation	393,000	235,800
Annual cost:		
Depreciation	$13,936.17	$17,466.67
Routine maintenance	1,200.00	1,780.00
Periodic maintenance		2,222.00
Total annual costs	15,136.17	21,468.67
Savings per year by use of concrete	6,332.50	

[1] Average for 16-inch concrete in 1953. Note that it is 67 percent higher than flexible.
[2] Used by Prof. R. A. Moyer and other economists.
[3] From 28th Annual Proceedings Highway Research Board.
[4] Based upon figures from 28 State highway departments.
[5] Two retreatments during service life.

NATURAL RUBBER BUREAU,
Washington 6, D. C., February 19, 1954.

Hon. WILLIAM E. HESS,
Chairman, Defense Activities Subcommittee,
House Armed Services Committee, Washington 25, D. C.

DEAR MR. HESS: Your letter of February 15 has been received. I was quite pleased to hear that the testimony being given at your committee hearings will be published and that I will receive a copy of the same.

I have very seriously weighed your question as to whether I might, as a result of our research work, contribute any information that would assist you in obtaining a better understanding of the problem under consideration. First, let me say that we are not a selling organization, but a techtnical group formed by the natural rubber producers for the purpose of studying rubber in bituminous paving work. Our work is in the field of science and the information we are gathering in our research endeavor is being passed along to the paving engineers all over the country.

Asphalt versus concrete, as you no doubt have learned by now, is a highly controversial subject. Anything we might add to your information would, of necessity, be confined to bituminous paving work. Our laboratory studies have progressed to the point where all indications show that rubber added to bituminous paving materials definitely improves such materials. The major improvements, briefly stated, are as follows: increase of stability; a bettering of cohesion; imparting elasticity; resistance to impact damage; and lowering of the susceptibility to temperature variations. Thus, the life of a bituminous pavement is lengthened and the maintenance cost during such time is lowered. A public official, we feel, is justified in spending public funds in using rubber in this bituminous paving work. The different types of rubber being studied do add these improvements in varying degrees.

The use of rubber in paving work does increase the cost, i. e. the material cost, not the actual laying cost. The paving engineer would be in a much better position to quote cost figures, as we do not attempt to keep such figures. We do know, however, that this increase in material cost is about 25 percent.

The many State and city officials who have visited our laboratory have complimented us on the completeness with which we have equipped our unit, also the care we have used in selecting our personnel. Anyone interested in paving

work is always welcome to visit our laboratory and freely discuss his paving problems with our technicians.

I trust that in some small way I have been able to add to your present information.

Very truly yours,

WILLIAM J. RYAN,
Research Engineer.

TREATISES ON AIRSTRIP PAVING BY DOUGLAS AIRCRAFT CO.

The following supplemental statement was presented by the Bureau of Yards and Docks of the Navy Department as a part of its presentation and studies. In the opinion of the Assistant Chief for Operations of the Bureau of Yards and Docks, this supplement is considered "one of the best treatises on the subject and very thorough in its analysis of the subject, the conclusions, and recommendations." The permission of Douglas Aircraft Co. and of the authors for use of this material has been obtained by the Navy Department.

ABSTRACT

Available information regarding the effect of aircraft jet engine wakes on airfield surfacing materials is summarized and discussed. These data show that the temperature of the exhaust gases incident on the pavement surface may be predicted from the exhaust-gas temperature, jet-nozzle angle, and height-to-diameter ratio. Temperatures in the pavement may then be predicted from the thermal properties of the material and the time of exposure. Moving nonafterburning aircraft do no damage because of the limited time of exposure; stationary nonafterburning and slowly moving afterburning aircraft may produce pavement-surface temperatures sufficient to cause appreciable damage. This damage starts at about 300° F. for asphalt and 800° F. for concrete pavements in current use. The problem of loose material being blown away is more severe than but similar to the situation with propeller slipstreams. Danger of fires from jet engine wakes seems remote.

INTRODUCTION

Jet aircraft are already in extensive use by the Armed Forces and are being considered by commercial operators. Their use is extending existing airport problems and introducing new ones, such as—

1. The effect of the hot high-velocity engine exhaust on airport surfacing materials.
2. Fuel spillage.
3. Noise.
4. Increasing wheel loading and tire pressures.

Only the first of these problems will be dealt with here.

With the increasing use of jet aircraft, this problem may become increasingly important to airport operators, naval aircraft carriers, and airframe manufacturers. Relatively little engineering data has been published in this country on the effect aircraft jet engine exhaust on airport surfacing materials. Most of the past experience has been with military combat aircraft, but is indicative of the coming problem with commercial and military transport jet aircraft.

This problem may be divided into two portions:

A. The temperature and velocity of the jet wake immediately above (incident upon) the ground surface, as affected by aircraft geometry and engine operating condition.

B. The reaction of various airport surfacing materials to surface temperature and velocity.

Because the temperature and velocity distribution patterns in a jet wake are similar, only one of these need be analyzed. The temperature variable has been chosen because damage to hard-surface paving materials is the more crucial problem. On the other hand, loose surface material will be affected more by the velocity. This portion of the problem being similar to, although more severe than the situation with propeller-driven aircraft, will receive only minor discussion.

GENERAL ASSUMPTIONS

Throughout this report, several general assumptions are made:

1. The aircraft or model jet is stationary with respect to both the ground surface and the free airstream.

As shown later, the time of exposure of a particular pavement area to the jet wake of a moving aircraft is insufficient to cause appreciable temperature rise. Consequently, hard surface pavements are not damaged. Conversely, loose surface materials, affected by the jet wake velocity, may also be damaged by moving aircraft.

2. All jet engine exit nozzles and test model nozzles are circular. This is the usual case. For the two exceptions, the "clam shell" variable area nozzle and the nozzle in which a center "bullet" protrudes into the exit plane, an effective diameter based on the minimum area arbitrarily has been used. The effect of devices used for minor adjustments to the exit area of fixed area nozzles has been neglected.

3. Ambient air temperature, T_a, is 59° F. (15° C.) unless otherwise stated. It may be that the gas temperature incident on the ground is insensitive to ambient air temperature. For one engine investigated, the correlation presented later yielded approximately the same temperatures incident on the ground for −40° F. to +100° F. air temperatures, due to the combined effects of ambient temperature T_a and the resulting changes in the jet temperature T_j.

4. The initial (undisturbed) ground temperature is equal to the ambient air temperature.

Where data are available to show that this is not the case, the air temperature should be used in finding the temperature incident on the ground, and the initial ground temperature in finding the ground temperature rise.

5. The ground or pavement surface is a uniform geometrically flat plane.

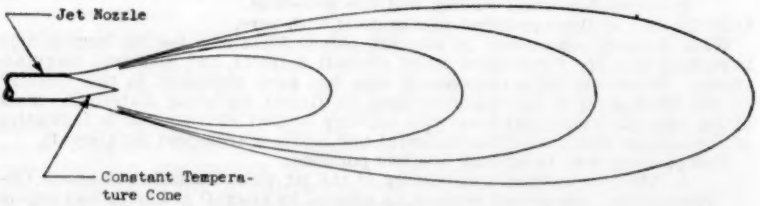
The effect of surface roughness, depressions due to prior damage, and pavement discontinuities has been neglected. Jet blast deflectors are not considered here.

CORRELATION OF AIRCRAFT GEOMETRIES

It is assumed that pavement damage occurs initially, and is most serious, at the point on the ground surface where the temperature of the incident jet wake is a maximum.

Several theoretical analyses have been made for the temperature distribution in an undisturbed jet wake, i. e., a jet expanding into quiescent air with no solid boundaries within the region of influence. These analyses do not appear capable of treating the effect of solid boundaries, such as the ground plane, nor are they completely satisfactory in other respect.

Consequently, these analyses have been abandoned, and less compliacted empirical correlations have been employed. A number of articles give experimental data describing the temperature distribution in an undisturbed jet wake expanding into quiescent air (reference 1). A sketch of such data is shown below in the form of a map of constant temperature contours.



Constant temperature profiles in an undisturbed jet wake.
NOTE.—Horizontal dimensions are one-half vertical dimension scale.

Several of these articles give correlations which, while not completely adequate, lead to the following assumptions:

1. The temperature distribution in jet wakes is axially symmetric about the jet nozzle centerline extended, as long as natural convection is not important. Natural convection becomes important only far beyond the present region of interest for jet aircraft or any reasonable model simulation thereof.

2. Geometric similarity of dimensions applies regardless of scale. Linear dimensions are usually presented in terms of jet nozzle exit diameters.

3. Temperature distribution patterns in jet wakes are similar, independent of the jet nozzle gas temperature. Temperature data show reasonable agreement when presented in the form of a temperature parameter, which is defined as the temperature rise over ambient air temperature of the gas at a point in the jet wake, divided by the jet nozzle gas temperature rise over ambient. In terms of the nomenclature adopted here, this temperature factor is:

$$\frac{T-T_a}{T_j-T_a}$$

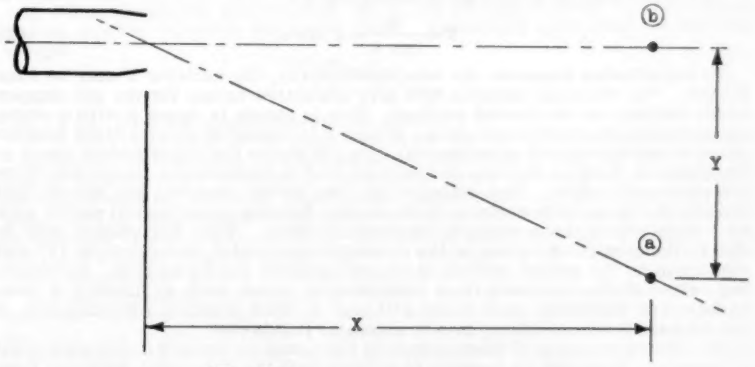
This form of a temperature factor later will be found convenient, as it is similar to temperature factors which result from several of the classical heat transfer equation solutions.

4. The above temperature factor is inversely proportional to distance downstream in the region downstream from the initial constant temperature cone (see sketch). This cone is on the order of five jet diameters long with the jet nozzle exit forming its base. The expression:

$$\left(\frac{X}{D}\right)\left(\frac{T-T_a}{T_j-T_a}\right)_{\text{centerline}} = \text{constant}$$

is a reasonable representation of the experimental data, although there is a small variation in the constant as other conditions change.

5. Downstream from the initial constant temperature cone, the locus of points where the temperature factor is a constant fraction of the value on the jet centerline at the same distance downstream forms a cone. The apex of this cone is approximately at the center of the jet nozzle exit, and its apex angle is a function of the temperature factor fraction chosen. Diagramatically, this states:



$$\frac{\left(\frac{T-T_a}{T_j-T_a}\right) AT\ \text{Ⓐ}}{\left(\frac{T-T_a}{T_j-T_a}\right) AT\ \text{Ⓑ}} = \text{a function of } \left(\frac{Y}{X}\right)$$

independent of the individual value of X.

6. Assumption 5 leads to the fact that the shapes of temperature profile vs radial distance (for a constant distance downstream) are similar, i. e., independent of the particular distance downstream. This fact has been used to extend experimental data into regions where measurements are difficult. Several mathematical functions have been used to represent this shape; it appears that the best of these is:

$$T-T_a = C_1\left[1+\cos(C_2Y)\right] \quad \begin{matrix} C_2Y<\pi \\ \frac{X}{D}>5.0 \end{matrix}$$

where C_1 and C_2 are constants. Other functions often used are the probability function, and the three halves power.

7. Other characteristics such as velocity, pressure, density, turbulence level, and chemical composition of the gas leaving the jet nozzle are apparently of secondary importance for the cases of interest here, and will be neglected.

As mentioned earlier, most of these assumptions are only in fair agreement with experimental data. The relationships described by these assumptions may be combined to yield the following empirical expression:

$$\frac{T-T_a}{T_j-T_a}=C_3\frac{1}{\frac{X}{D}}\left[1+\cos\left(C_4\frac{Y}{X}\right)\right]\begin{matrix}C_4\frac{Y}{X}<\pi\\ \frac{X}{D}>5.0\end{matrix} \qquad (1)$$

where the constants C_3 and C_4 are to be evaluated from experimental data. Trial has shown that while this expression is only approximate, even for the temperature distribution in a single jet wake, it appears to be as good as any similar expression available. Average values for the constants appear to be:

$$C_3=2.5$$
$$C_4=12.8 \text{ (radians)}$$

Because of lack of sufficient information, it will be assumed for this analysis that the effect of the ground plane on the temperature distribution in the jet wake is negligible (see p. 233, paragraph A). The equation of the ground plane then may be substituted into equation (1) to determine the temperature distribution incident on the ground surface. Experimental values for both these temperature distributions are given in reference 2.

This analysis may be simplified by limiting it to the plane which is perpendicular to the ground surface and which contains the jet centerline. The assumptions leading to equation (1) indicate that this is a plane of symmetry and that this plane will contain the maximum temperature incident on the ground. Figure 1 shows the location of the pertinent variables in this plane.

The equation of the ground plane (line) is now:

$$Y=\frac{H}{\cos\alpha}-X\tan\alpha \qquad (2)$$

By substituting equation (2) into equation (1), the variable Y may be eliminated. The resulting equation will give calculated values for the gas temperature incident on the ground surface. This is shown in figure 2 with a corresponding set of experimental data. Figure 2 is typical of several other comparisons of calculated and experimental data; it shows the experimental curve to be displaced, both in distance downstream and in temperature magnitude, from the calculated values. The shapes of the two curves, however, are similar, and the calculated curve is useful in interpolating between experimental points, such as for obtaining the maximum temperature value. This discrepancy may be due to the particular values of the constants substituted into equation (1) and constraint by the ground surface of the cool ambient air for mixing. By obtaining values of the constants from experimental curves such as figure 2, a more satisfactory prediction may result, although a third constant (displacement of the jet wake from centerline) may be necessary in this case.

The maximum value of temperature on plots such as figure 2 is the main point of interest. It should be possible to differentiate the expression resulting from equations (1) and (2) to obtain the maximum value of the temperature. This, however, results in a cumbersome expression which has no apparent explicit solution. It was found by numerical evaluation that two of the dimensionless groups may be combined to yield the following approximate functional relationship:

$$\left(\frac{T_s-T_a}{T_j-T_a}\right)\left(\frac{H}{D}\right)=f(\alpha) \qquad (3)$$

This shows that for a given jet engine, the maximum gas temperature incident on the ground surface is inversely proportional to the height of the jet exit above the ground. Figure 3 gives a comparison of calculated and experimental values for this functional relationship. These curves show the same temperature discrepancy as figure 2. Any discrepancy in the downstream distance at which the maximum temperature occurs does not directly affect figure 3.

Several comments are in order regarding the experimental data shown on figure 3. Throughout this report, the ground plane temperature, T_s, is defined as the jet wake gas stagnation temperature incident on the ground surface.

As shown later, temperatures on the surface, or at a finite depth below the surface, exhibit an appreciable time lag from the incident gas temperature. Some of these data have been corrected analytically, by the methods given later in this report (equation 4), to make them comparable. At least part of the scatter of the experimental data on figure 3 may be due to the questionable accuracy of these corrections, due to lack of knowledge of the exact thermal properties of the pavement materials used and the surface heat transfer coefficient. Specifically:

A. Reference. 2 (⊙): Data represent thermocouples at the surface of an "insulating" plate. No corrections used.

B. Reference. 3 (▽ and △): Data represent the hottest of four thermocouples at the surface of a concrete slab, after consecutive periods of 3 minutes at 60 percent power (▽) and 3 minutes at 100 percent power (△). Corrected for surface lag only, correction factors being on the order of 1.4. Observed temperatures may be low due to a thermocouple not being located at the highest temperature point. (See fig. 2.)

C. Reference 4 (+): Situation not described. No corrections used.

D. Reference 5 (×): Data represent thermocouples at one-half inch depth in concrete after a 13-minute-run period. Corrected for surface plus depth lags, correction factors being on the order of 2.6.

Decreased accuracy is expected as the correction factor increases.

Several interesting facts may be deduced from the experimental data shown on figure 3.

A. For low values of α, the angle between the jet centerline and ground plane, the mean of the experimental data shows higher temperatures incident on the ground surface than predicted by the undisturbed jet wake temperature distributions. This is due to the fact that the ground surface restrains the cool air available for mixing with the hot jet in this region. Because such restraint may result from any surface, it is also expected that adjacent aircraft surfaces such as wings or flaps may have a small effect on maximum ground temperatures. It should be noted that all the data shown were obtained with no solid bodies in or adjacent to the jet wake except the flat ground plane.

B. While not shown, the values of (H/D) for the experimental points of figure 3 show random variation and not a trend. Apparently combining the variable groups

$$\left(\frac{T_s - T_a}{T_j - T_a}\right)_{\max}$$

and (H/D) does not produce the scatter shown.

C. Within the scatter of the data, values for the model jet (a 1-inch diameter pure air jet of relatively low temperature differential) and for full-scale jet engine exhaust show reasonable agreement. This indicates that reasonable confidence may be placed in experimental work performed at model scale (dimensions and temperature factor) and extrapolated to full scale by use of these parameters. There is some evidence that the jet nozzle pressure or density ratio will have a small effect on spreading of an undisturbed jet. The scatter of the data presented on figure 3, however, prevents any conclusions on the matter.

The nondimensional correlation of figure 3 may be used to estimate the maximum temperature incident on the ground surface for a given airplane. An example of this is given in figure 4, showing the estimated maximum temperature of the exhaust gases impinging on the ground surface, as a function of the height and angle of the exhaust, for the commercial version of a large turbojet engine soon to be available. The curves of figure 4 have been computed from the "design center" fairing of the experimental data on figure 3, and represent a "best guess." Using the upper limit of the bulk of the experimental data yields temperatures on figure 4 approximately 50° F. higher. As mentioned previously, the only apparent reasons for the data on figure 3 to be higher than the true maximum temperature are experimental accuracy and overcorrection for surface or subsurface timelag.

The table of operating experience contains temperature estimates and comparisons of these estimates with test data for aircraft for which sufficient unclassified information is available. Again the experimental temperature data are of questionable validity because of lack of a sufficient statement as to the location of the temperature sensing device, i. e., gas temperature incident on the surface, surface temperature, or subsurface temperature. The estimated temperatures are the highest of these three.

Limiting engine operation to partial throttle reduces the jet temperature rise less than might be expected. For example, it has been found that one large bomber engine idles at 43 percent, and a smaller fighter type at 73 percent of the maximum jet temperature rise, $T_j - T_a$.

EFFECT OF TEMPERATURE ON AIRFIELD SURFACING MATERIALS

Effect of time

An analysis has been made to determine the effect of exposure time on ground temperatures. It is unlikely, of course, that the engines of operational jet aircraft will be run for long periods of time on the ground, due to their high rate of fuel consumption.

The subsurface temperature distribution produced by a hot jet impinging on the ground may be studied by considering a semi-infinite solid suddenly exposed to a fluid at a higher temperature. Assuming that the pavement composition and initial temperature are independent of the depth, Z, and that the dimensions and thermal properties are independent of the local temperature T_s reference 6 gives, as an analytical solution:

$$\frac{T_s - T_a}{T_s - T_o} = 1 - \text{erf}\left(\frac{B_i}{\sqrt{4F_o}}\right) - e^{(B_i + F_o)}\left[1 - \text{erf}\left(\frac{B_i + 2F_o}{\sqrt{4F_o}}\right)\right] \tag{4}$$

where:

B_i=Biot number$= \dfrac{h\,Z}{k}$

F_o=Fourier number$= \dfrac{h^2 a\theta}{k^2}$

$\text{erf}\ u$=*Error function of* $u = \dfrac{2}{\sqrt{\pi}} \displaystyle\int_o^u e^{-v^2}\,dv$

and the remaining symbols are defined in the nomenclature. This shows that the temperature rise of any point in the pavement, divided by the temperature rise of the gas incident upon the surface of the pavement, is a function of the time, θ; of the depth, Z, of the point in question; the thermal properties, k and a, of the pavement; and the surface heat transfer coefficient, h. Reference 6 also gives numerical solutions of equation (4) in graphical form.

Equation (4), based on theory, assumes no heat transfer parallel to the surface, and has been shown to be an excellent representation of experimental data when the constants are reasonably accurately evaluated. The constants used here (given in figs. 5 and 6) were selected from published literature with the exception of h, which was calculated from a modified form of the usual equation:

$$\frac{h\,x}{k} = C_5 (R_e)^{C_6} (P_r)^{C_7} \tag{5}$$

for a 400 feet per second velocity, 20 feet effective length, and air at 340° F.

No attempt has been made to check the curves resulting from these assumed constants (figs. 5 and 6) against experimental data for this situation. This should be done in a complete evaluation of experimental apparatus and data.

Several numerical solutions for equation (4) are given in figures 5 and 6. Figure 5, the temperature distribution in concrete as a function of the depth, Z, with time, θ, as a parameter, shows that the temperature penetration into the pavement is relatively shallow. Experimental data lead to the same conclusion. This indicates that damage will be confined to the exposed surface of the pavement, with relatively little structural weakening of the material except that visible on the surface. Test data on the compressive strength of concrete after heating is given on figure 7 as an indication of the structural weakening expected. (See description of concrete paving.)

Figure 6, the surface temperature ($Z=\theta$) of concrete and asphalt pavements as a function of time, θ, shows that:

1. The surface temperature of asphalt will rise faster than that of concrete. This is due only to the change in the thermal conductivity, k, and diffusivity, a, which, depending upon the aggregate used in the paving material, may also vary.

2. The problem may be alleviated somewhat by limiting the continuous engine running time at a fixed location to about one minute. References 7 and 9 give average times experienced at an operational base (military jet aircraft) as:

[Minutes]

	Single-engine aircraft	4-engine aircraft
Starting	3.5	10.0
Pretakeoff	1.5	2.5
Maintenance	14.0	14.0

The maintenance times listed above are sufficient to cause nearly the maximum amount of surface temperature rise for a particular aircraft.

3. Temperatures reached in paving materials when nonafterburning aircraft are moving are no problem, due to the short time of exposure of the pavement surface to the jet wake. This is amply borne out by experience.

The temperature parameter of equation (4) is in a form convenient to apply as a correction factor to the temperature parameter of equation 3:

$$\frac{T_z-T_a}{T_s-T_a}\times\frac{T_s-T_a}{T_j-T_a}=\frac{T_z-T_a}{T_j-T_a}$$

As mentioned earlier, this type of correction has been used to make the various sets of experimental data presented in figure 3 comparable.

Damage to unpaved areas

This portion of the problem is much the same as that produced by propeller-driven aircraft, accentuated by higher power levels. Damage here consists of material removal, in various forms from dust clouds to large pieces (to 100 pounds) which may be thrown several hundred feet. Application of a thin asphalt treatment apparently is not the solution (reference 7), as it only increases the size of the pieces of material removed. Soil cement, a mixture of portland cement and earth, has been partially satisfactory when not subjected to traffic. A remedy currently being utilized is some form of steel mat or mesh, firmly staked down. In certain cases, steel runway matting has been rolled up by the jet wake. Such steel mat reduces, but does not eliminate, material removal.

The above-mentioned material removal may be serious to established airports in two ways:

1. By removing the grading at the edge of paved areas, structurally weakening these areas. (One case of this was noted at the Los Angeles International Airport, where dirt had been removed at the edge of a concrete holding slab to a depth of 15 inches, exposing the subgrade and causing mud puddles. Wire mesh, similar to "cyclone" fencing material, had been only partially successful in halting this damage.)

2. Danger or discomfort from the material removed. This includes window breakage from gravel, reduced visibility, personnel discomfort, etc.

Damage of this type, due primarily to the velocity rather than the temperature in the jet wake, is not expected to show the time dependency that pavement damage does. Moving aircraft will produce some damage, although the amount of material removed is to some degree a function of the time of exposure.

The following is quoted from reference 12: "In Korea, jet blast erosion of the base (subgrade) under pierced steel plank landing mats has been a principal cause of runway failure. This erosion causes ruts in the runways and creates uneven transverse grades which are particularly dangerous for jet planes carrying wingtip tanks. Buckling of this planking and breaking of connective bayonets has reduced normal tire life 60 to 90 percent. Many expedients have been tried, such as placing rice straw bags or mats, or opened burlap sandbags on the ground under the steel planking and treating them with asphalt cutback. None of the expedients is entirely satisfactory, and over a period of time blast erosion will ruin most pierced steel plank runways."

Danger of fires

No cases of fires due to jet wakes, to the author's knowledge, have been reported. Apparently combustible materials blow away before reaching their ignition temperature. Attention is called to tests made with the Canadian Avro Jetliner

(reference 8). A flannel cloth mop, soaked in 100 octane gasoline, was held at several locations in the jet wake both with the engines running at idle and at takeoff conditions. At no time did the mop show any tendency to ignite.

Description of asphalt paving

Technically known as asphaltic cement concrete, the common asphalt paving may be classified as a semiflexible thermosetting material. It commonly consists of aggregate (gravel) with petroleum derivatives forming a water repellent binder. The binder and aggregate are mixed hot, spread in place, and compacted (rolled). It is usually used as a surfacing material, 4 to 16 inches thick, with a specially prepared subgrade, up to 6 feet thick, forming the load-supporting structure.

Asphalt paving is also used as an overlay, either to reinforce existing pavement or to resurface pavement damaged either locally or generally. It is very common to apply a 4-inch thick surface of asphalt paving to cracked or broken concrete paving.

In use, the surface of asphalt paving partially oxidizes, which further hardens the exposed layer. Repeated tire loads also tend to further compact the materials, reducing the voids (air pockets) in the paving, thereby increasing its water-repellent and load-bearing qualities. This accounts for the fact that old asphalt paving is often considered superior to newly laid material.

A common cause of pavement failure is water entering the subgrade, reducing its load-bearing quality. As asphalt paving, in the past, has had a small tendency to be porous, a thin waterproofing "seal coat" has often been applied to the surface of the pavement. This "seal coat" is also an asphalt-aggregate mixture, having a smaller size aggregate and higher percentage asphalt than the paving mixture. Modern paving practice has considerably reduced the water permeability of asphalt pavement.

Damage to asphalt paving

Because asphalt paving is designed as a semiflexible material, apparently the softening of the asphalt due to heating does not seriously affect the structural qualities of the pavement. Wheels, rolled through areas softened by the heat of a jet blast, produce only small surface deformation.

Evaluation of damage to asphalt paving by various sources has led to conflicting statements. Physically, this damage ranges from surface discoloration to complete removal, in the extreme case, of the pavement and a portion of the subgrade. The worst damage traceable to nonafterburning aircraft outside of maintenance or test areas is removal of material to a depth of about 2 inches, as illustrated by figure 8.

The effect of surface discoloration, which probably starts at about 250° F., at worst, is to decrease the water-repellent quality of the pavement, permitting eventual breakdown of the subgrade. Actual material removal, which probably starts at about 300° F., appears to be to some degree a function of the time, as well as the temperature, involved. As shown in figure 9, most cases of material removal in the past have been elliptical areas on the order of 3 by 8 feet, and not exceeding 1 inch in depth. The asphalt binder is removed first, the aggregate being removed only when loosened. This type of damage leaves the roughened surface shown in figure 10, and an almost negligible depression, with regard to runway level. Obviously, however, it will reduce the water-repellent and structural qualities of the pavement. As the jet aircraft traffic increases, the material removal due to repeated jet effects in the same location will probably be cumulative.

The temperatures mentioned above are the pavement-surface temperatures, not the gas temperature (see effect of time), and must necessarily be approximate due to variation of the properties of the asphalt and aggregate used. The following unpublished estimates of temperature susceptibility are noted:

Reference	Temperature	Statement
Mr. Lackey of the Asphalt Institute	300° F.	Limiting safe temperature.
Mr. Bishop of the United States Naval Civil Engineering Laboratory.	400° F.	Erosion definitely occurs with optimum composition.

Further data on temperatures are included in the table of operating experience.

Description of concrete paving

The most commonly used material falling under this description is technically known as portland cement concrete, and is classified as rigid pavement. It is usually laid in thickness of 4 to 22 inches, depending on the design loads and bearing capacity of the soil or prepared subgrade. In the past, concrete has been laid in monolithic strips 20 to 25 feet wide, with stress relief joints at 15- to 25-foot intervals to accommmodate expansion and contraction. These sections were sometimes joined with steel dowels to prevent vertical displacement, and the joints between sections, up to three-fourths inch wide, were filled with an asphaltic sealing compound to prevent entry of foreign incompressible material and water. It is now recommended that these joints be sawed or cast slots one-fourth inch less in width, 1½ inches deep, at about the same spacing. These slots lead to "controlled" cracking, and may be filled with asphalt, asphalt-rubber mixtures, or asbestos. "Aggregate interlock" action replaces the dowels in preventing vertical displacement.

The concrete used for runways is impervious to water, but any cracks or joints may be filled with a flexible material to completely protect the subgrade from surface water. This flexible material also excludes foreign incompressible material which could cause local failure under conditions of seasonal temperature variation.

Comparative prices depend somewhat on location, but concrete paving is usually somewhat more expensive in first cost than asphalt paving that has been designed for equal load-carrying capacity.

Damage to concrete paving

Because concrete paving supports its loads somewhat in the manner of a beam, its structural strength is important. Figure 7 indicates the reduction in strength of small concrete specimens heated for relatively long periods of time. However, figure 5 indicates the high temperature penetrate only a relatively small distance into the pavement, and therefore this phenomenon is not expected to cause trouble.

The heat weakening of concrete mentioned above is probably due to loss of water of hydration in the cement binder. In one case a 45-minute application of a jet blast caused surface deterioration in concrete paving.

Figure 5 indicates that a high thermal gradient may occur near the surface of concrete paving. Because concrete is a rigid material, this leads to high thermal differential expansions. The physical result is called "spalling" and consists of flaking off on the surface of the concrete, at times with explosive violence. This may occur at relatively low pavement temperatures if the thermal gradient is sufficiently great. The results of this phenomena are expected to be cumulative when an area is subjected to repeated jet wakes.

Based on past experience, estimates of the maximum gas temperature permissible over concrete range from 800° to 900° F., but are ill defined. Permissible temperatures are expected to be dependent upon the composition of the aggregate used.

In the past, trouble has been experienced in retaining joint sealer (asphalt) in concrete expansion joints exposed to jet blasts. Modern practice with narrower joints and improved joint sealers are expected to alleviate this problem. Studies are also in progress to determine improved joint-sealer materials.

Taxiway markings

No paint materials have been found to date which will withstand the effect of both jet wakes and tire abrasion. Lighted runway markers, containing glass, also must be protected from direct jet wake, due to both temperature and loose flying objects in the jet wake.

Aircraft damage

Uneven pavement surfaces resulting from material removal by and local failure due to jet wakes are obviously undesirable in several ways such as—

1. Reduced wingtip-ground clearance in the case of wing spans long compared to the distance between landing gear.
2. Increased landing gear strut normal loading.
3. Difficulty in taxiing.

Several less obvious, but serious effects, are—

1. The loose material removed may remain on the pavement surface to cause "rock bruise" damage to tires, or be aspirated into the air intakes of low-slung jet engines.

2. One case has come to the author's attention where asphalt pavement, loosened by the jet wake, splattered (in a hot sticky state) on the airplane's horizontal tail surfaces. This causes a cleanliness problem and could conceivably result in particles lodged in the gap between the stabilizer and elevator, restricting control surface movement.

No cases have been reported, to the author's knowledge, where this loose material, or concrete pavement spalling, has resulted in aircraft skin punctures, but this appears to be a possibility.

CONCLUSIONS

The following conclusions may be drawn regarding the effect of aircraft jet engine wakes on runway surfaces currently in use or soon to be available:

1. Effect of time

Existing nonafterburning aircraft damage pavement surfaces only when stationary. When afterburning or using jet assistance equipment, damage may occur only when the aircraft are moving relatively slowly.

2. Concrete pavement

Existing nonafterburning operational aircraft produce only negligible damage to concrete pavement, and even this damage should be relieved by current paving procedures. Afterburner equipped jet aircraft may require certain limitations as to location and duration of afterburning to reduce damage to tolerable levels.

3. Asphalt pavement

Several current operational jet aircraft, not equipped with afterburners, will damage asphalt pavement during stationary operation. Limiting engine operation to partial throttle alleviates this damage only a small amount.

4. Unpaved areas

No completely satisfactory solution is available for unpaved areas that receive more than occasional use.

5. Fires

Experience has shown that the fire hazard due to jet wakes is negligible.

6. Prediction of damage

The conditions under which pavement damage may occur can be predicted if the temperature, height-to-diameter ratio, and angle of the jet at the nozzle exit, and the temperature tolerance of the pavement are known. Certain combinations of these factors, which may be quite restrictive when afterburning and asphalt pavements are involved, are definitely not tolerable. Recurrent damage probably will be cumulative.

The accuracy of the gas temperature predictions by the methods given here are about $\pm 50°$ F., due to scatter of the experimental data. Estimates of the tolerable temperatures for various types of pavements in current use are also $\pm 50°$ F., due to only partially known physical properties. Since 50° F. represents approximately the margins from negligible to appreciable and from appreciable to serious damage, conclusions based on these methods should be used only as a guide.

On the basis of these conclusions, certain recommendations may be made:

1. Airport pavement should be concrete at all locations where jet aircraft are expected to be stationary with engines operating, while asphalt pavement is optional for taxiways, the center portion of runways, etc. This concrete should contain only suitably selected aggregate when afterburners are to be used.

2. Maintenance areas for extended stationary operation of afterburners may require special "blast pits" or water cooling.

3. Aircraft designers should devote increased attention to the geometrical position of the jet engine exhaust. Disregard of this factor can lead to increased operating cost. In this connection, it might be added that the Armed Forces apparently have concluded that aircraft performance should not be sacrificed for ground facility limitations.

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3. The Effects of Jet Aircraft on Airfield Pavements, by J. A. Bishop, given at the ASCE convention, March 3–6, 1953, and unpublished data supporting this paper.
4. Performance Characteristics of Jet Nozzles, by G. S. Schairer, Third Anglo-American Aeronautical Conference, 1951.
5. An Investigation of the Heating Effect of a Jet Engine on a Concrete Surface Behind the Tail Pipe, by A. G. Earl and C. Long, R. A. E. Technical Note No. Gas 28, June 1946 (ATI No. 8679).
6. Heat Transfer Notes, by L. M. K. Boelter, V. H. Cherry, H. A. Johnson, and R. C. Martinelli, University of California Press, 1946.
7. The Effect of Jet Aircraft on Airport Pavements, by G. McFadden, ASCE convention preprint, Paper No. 92, March 3–6, 1953.
8. Operational Aspects of Turbo-Jet Transports, by R. D. Speas, IAS preprint No. 344, June 27–28, 1951.
9. Symposium on Airfield Pavements for Jet Aircraft, sponsored by the United State Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme, Calif., April 17–18, 1952, and unpublished data supporting several of these papers.
10. Discussion of Jet Aircraft Aerodrome Needs, ICAO Bulletin, January–February 1953, page 12.
11. Effect of Long Exposure of Concrete to High Temperature, Portland Cement Association paper ST 32, August 1951.
12. Engineer Training Bulletin, the Engineer School, Fort Belvoir, Va., No. 4, April 1953.

The following publications also contain applicable data:

13. Interim Report on Heat and Blast Effects on Pavements, prepared for Office, Chief of Engineers, by Waterways Experiment Station, Vicksburg, Miss., December 1952.
14. Air Ministry Directorate General of Works, Technical Publication 103/50, London, January 1950 (G.253145/MEB/12/49/50).

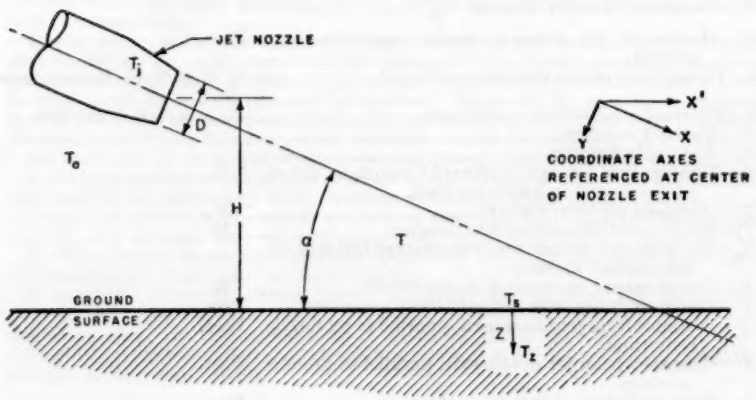
NOMENCLATURE

a—Thermal diffusivity of paving material	Square feet per hour.
B_i—Generalized Biot number, $\frac{hZ}{k}$	
C—Constants, defined where used	
D—Diameter of jet exhaust nozzle	Inches.
F_o—Boundary Fourier number, $\frac{h^2a\theta}{k^2}$	
H—Height of jet exhaust nozzle centerline from ground.	Feet.
h—Forced convection thermal coefficient	B. t. u./° F. hour-square feet.
k—Thermal conductivity coefficient	B. t. u./° F. hour-feet.
P_r—Prandtl number	
R_e—Reynolds number	
T—Temperature at any particular point in space (stagnation if in a moving gas).	° R.
T_a—Ambient air temperature	° R.
T_j—Jet exhaust stagnation temperature	° R.
T_s—Jet wake gas stagnation temperature incident on the ground surface.	
T_z—Temperature at depth Z in pavement	° R.
Y—Radial distance from jet centerline extension	Feet.
X—Distance from jet nozzle exit, parallel to jet nozzle centerline.	Feet.
X'—Distance from jet nozzle exit, parallel to ground surface.	Feet.
Z—Distance below pavement surface	Feet.
α—Angle between jet centerline and ground surface (positive when after end of engine is tilted downward).	Degrees.
θ—Time	Hour.
( ) Max—Maximum value in a particular plane	

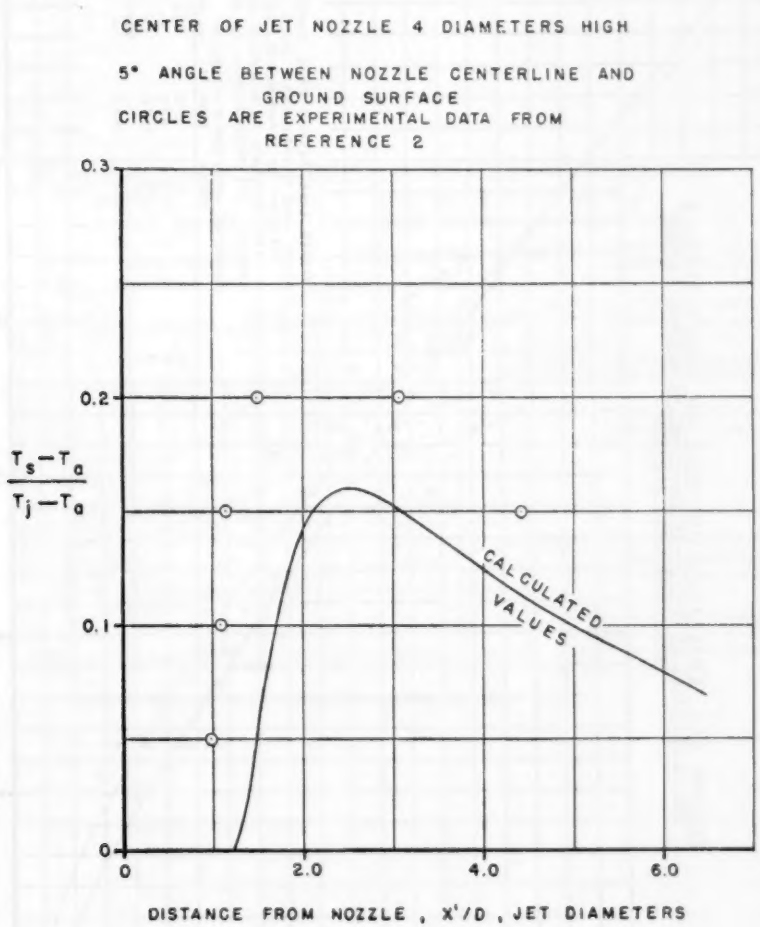
Operating experience with jet aircraft

Aircraft engine	Engine location configuration	H inches	α degrees	Effective D inches	T_j °F.	Estimated T_s °F.	Measurement T_s or T_z °F.	Remarks	Reference
"Fighter"		3.5D	0		1,200	199		Minimum desirable values for H and α.	10
							253	On surface of asphalt pavement, no damage. Time not stated.	9
"Bomber"							385	Maintenance runup on asphalt pavement, serious erosion.	9
							399	Pavement temperature in asphalt, minor erosion. Time not stated.	
B-47	Nacelle on strut under wing.							Serious damage to asphalt pavement by outboard engines after 3 minutes.	9
F7U-1	Pair in fuselage.		7.5 or 13.		1,274		531	Pavement surface temperature after 4 minutes.	9
F9F-2	Single under fuselage.		3.5		1,310		410	do	9
AVRO C102	Pairs in wings.							Gouging of asphalt in runup areas.	8

GEOMETRY

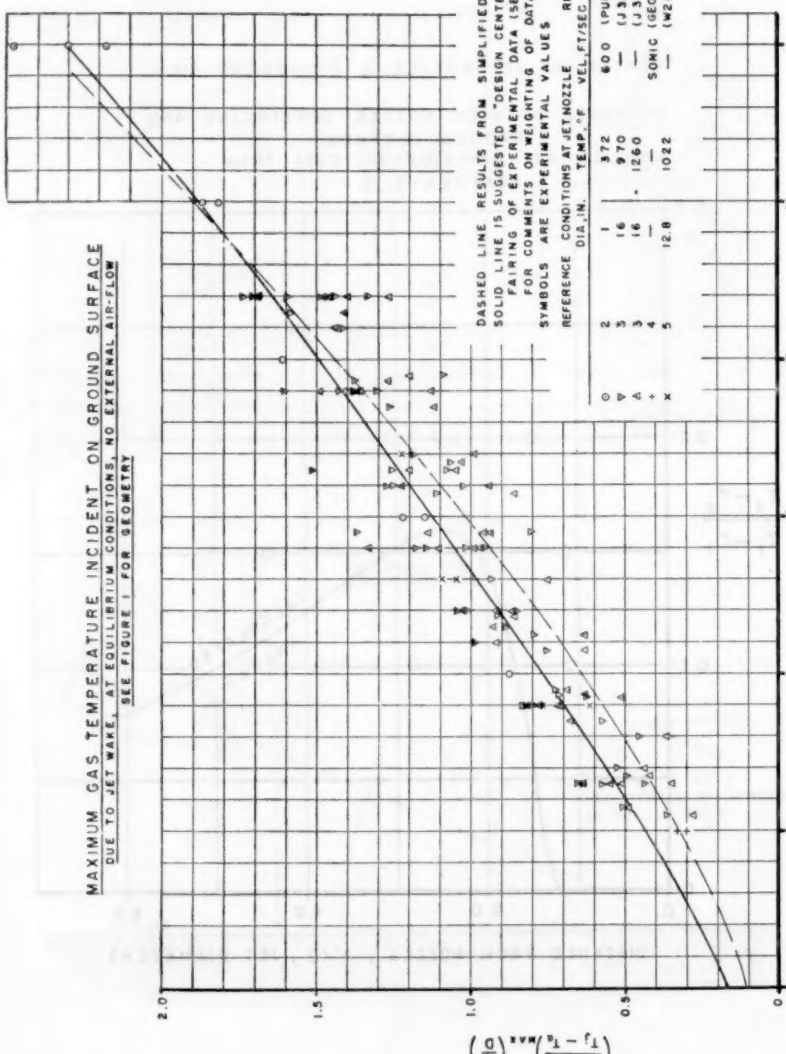


TEMPERATURE DISTRIBUTION IN GAS INCIDENT ON THE GROUND SURFACE



43649—54——17

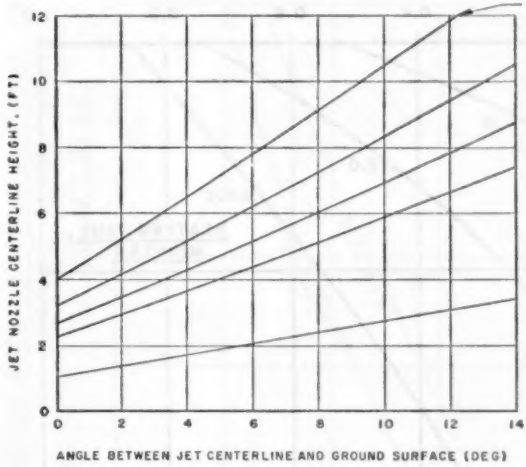
FIGURE 3


MAXIMUM GAS TEMPERATURE INCIDENT ON GROUND SURFACE
DUE TO JET WAKE, AT EQUILIBRIUM CONDITIONS, NO EXTERNAL AIR-FLOW
SEE FIGURE 1 FOR GEOMETRY
DASHED LINE RESULTS FROM SIMPLIFIED ANALYSIS
SOLID LINE IS SUGGESTED "DESIGN CENTER" FAIRING OF EXPERIMENTAL DATA (SEE PAGE 10 FOR COMMENTS ON WEIGHTING OF DATA)
SYMBOLS ARE EXPERIMENTAL VALUES
REFERENCE | CONDITIONS AT JET NOZZLE DIA., IN. | TEMP., °F | VEL., FT/SEC | REMARKS
2 | 1 | 372 | 600 | (PURE AIR)
5 | 16 | 970 | — | (J3545 TURBOJET)
3 | 16 | 1260 | — | (J3545 TURBOJET)
4 | — | — | SONIC | (GEOMETRY UNKNOWN)
5 | 12.8 | 1022 | — | (W28/230 TURBOJET)
$\left(\frac{T_x - T_a}{T_j - T_a}\right)_{MAX}\left(\frac{H}{D}\right)$
2.0
1.5
1.0
0.5
0
-5
0
5
10
15
20
25
ANGLE BETWEEN JET CENTERLINE AND GROUND SURFACE, Θ, DEGREES

ESTIMATED MAXIMUM GAS TEMPERATURE INCIDENT ON THE GROUND SURFACE

ENGINE A
NACA STANDARD DAY

23.7 INCH DIAMETER NOZZLE
960°F JET TEMPERATURE AT NOZZLE



250°F { NEGLIGIBLE DAMAGE TO ASPHALT PAVEMENT

300°F { INITIAL EROSION OF ASPHALT PAVEMENT

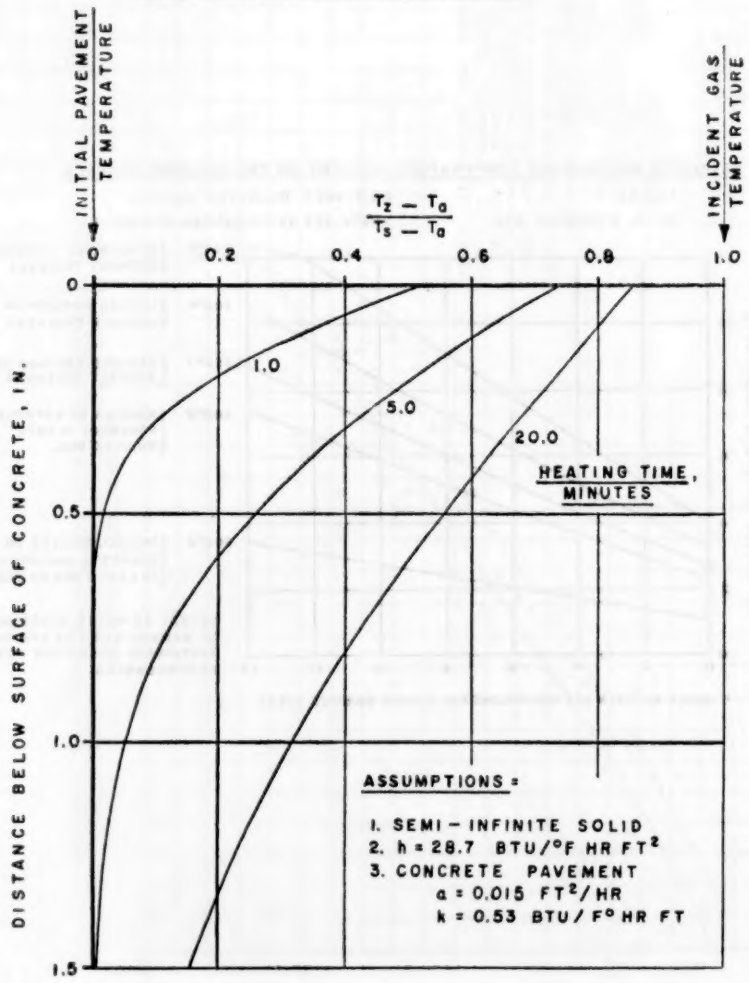
350°F { SERIOUS EROSION OF ASPHALT PAVEMENT

400°F { EROSION OF ASPHALT PAVEMENT IN LESS THAN 1.0 MIN.

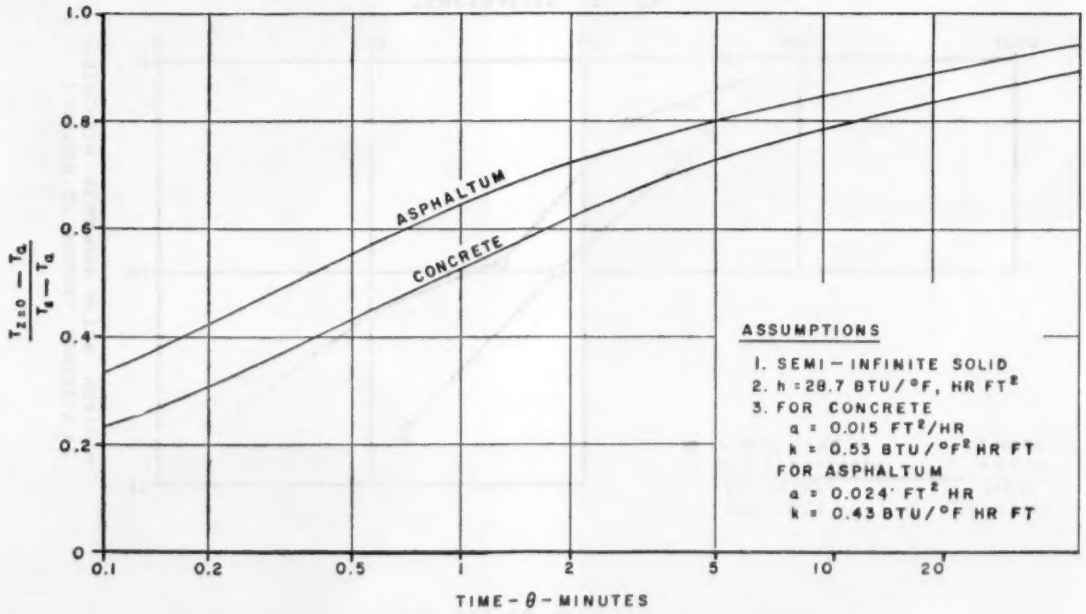
800°F { INITIAL DAMAGE TO CONCRETE PAVEMENT IN LESS THAN 20 SEC

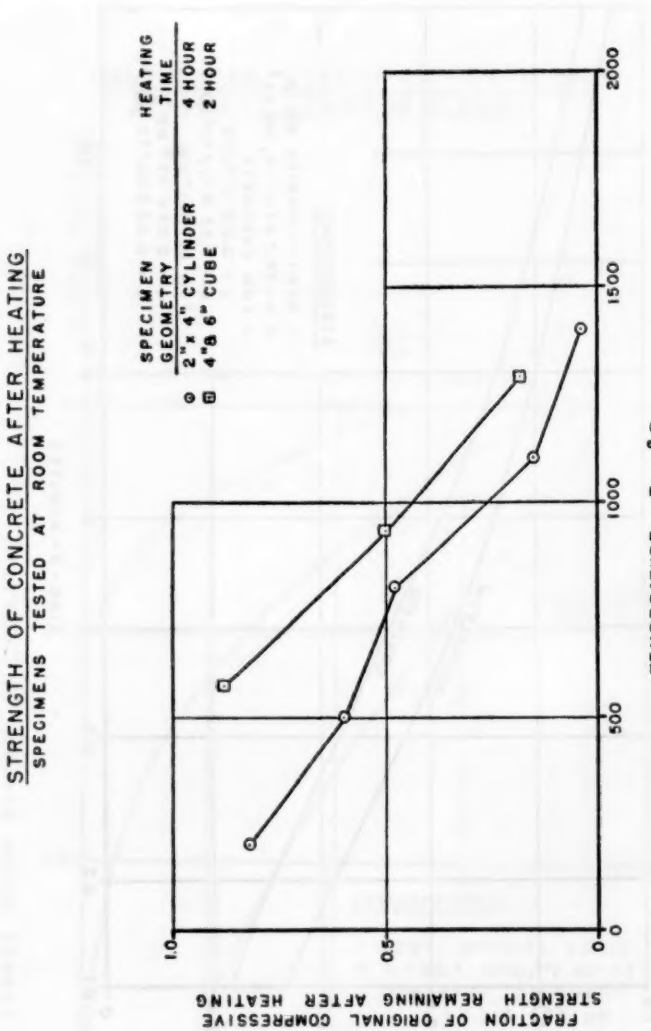
EXCEPT AS NOTED, STATEMENTS OF DAMAGE ARE FOR APP. 5 MIN STATIONARY OPERATION NON-AFTERBURNING

CALCULATED EFFECT OF DEPTH ON PAVEMENT TEMPERATURE

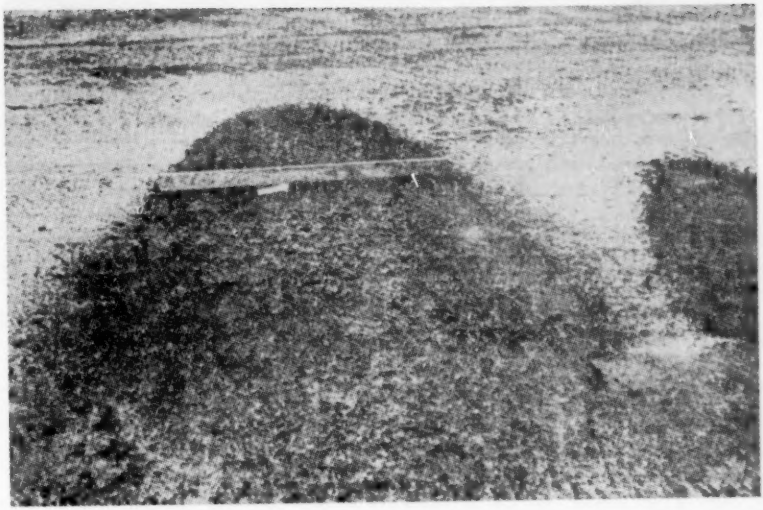


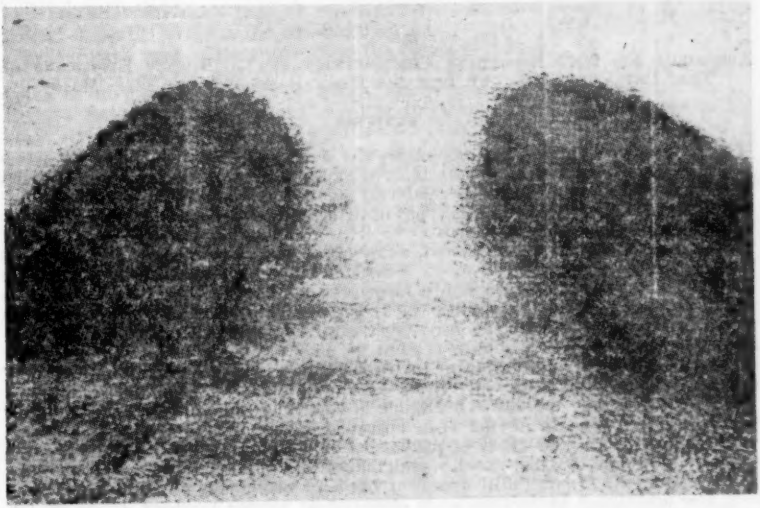
CALCULATED EFFECT OF TIME ON PAVEMENT SURFACE TEMPERATURE DUE TO JET BLAST

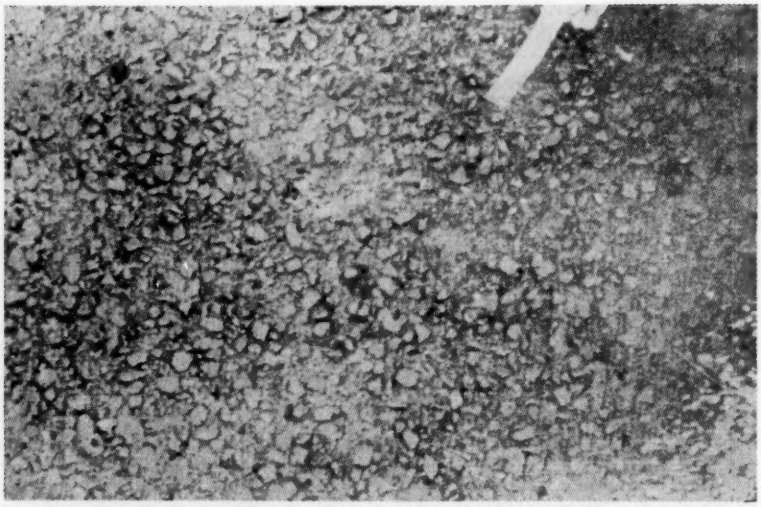




DATA FROM REFERENCE 11.







(Supplement statement submitted by Flinkote Corp. and United States Rubber Co.)

ADDENDUM NO. 2 TO REPORT ON CONSTRUCTION OF TAR-RUBBER EXPERIMENTAL TEST PAVEMENTS PRESQUE ISLE AIR FORCE BASE, PRESQUE ISLE, MAINE

SYNOPSIS

Inspection of experimental asphaltic, tar and tar-rubber concrete test pavements during November 19 and 20, 1953, at Presque Isle Air Force Base, indicated that damage to the pavements is relatively small, after approximately 5,900 landings and takeoffs by 37 different types of aircraft which operated during the 12-month period since construction.

Surface erosion of varying extent, as revealed by sizes and depths of elliptical blast patterns, was observed at 12 locations, whereas only 2 such areas were observed during the initial 6-month inspection. Although observations are definitely not conclusive at this time, the trend relative to the performance of the pavements seems to favor the tar-rubber mixtures, depth of erosion in several asphaltic concrete panels, due to normal jet aircraft operations, being definitely measureable, whereas in adjacent tar-rubber panels the corresponding depth of erosion is not measurable.

Damage from fuel spillage is negligible at this time; no additional softening of the various pavements having been observed, although several jet fuel stains were visible on all four types of pavement. The original localized area on the taxiway tar concrete panel which was damaged as a result of spillage, as reported in addendum No. 1, was still apparent but had not enlarged in extent.

A few additional haircracks were observed at joints; however, these are attributed to cold weather construction and are considered insignificant. One small 10-foot long by ⅛-inch maximum width crack (transverse with respect to direction of paving) was observed at a construction joint in a Flintbinder panel; this is believed to have been caused by heat and blast from a jet aircraft, as the crack is located in the center of a blast pattern.

Although raveling of pavement at joints was observed at a few new locations, there was no indication of an increase in extent of raveling in previously reported areas.

1. *Purpose.*—The purpose of this addendum is to report the condition of the subject experimental airfield test pavements, consisting of bituminous concrete constructed with asphalt cement, tar, and 2 types of tar-rubber, after 12 months of use by various types of aircraft traffic.

2. *Scope.*—This report is the second of 6 scheduled semiannual pavement-condition reports being issued as addenda to Report on Construction of Tar-Rubber Experimental Test Pavements, Presque Isle Air Force Base, Presque Isle, Maine, dated January 1953, and summarizes observations made during the period November 19 and 20, 1953, relative to the condition of the 4 types of pavements 12 months after their construction. Also summarized herein is the aircraft traffic history for the 12-month interval.

3. *Authorization.*—Authorization for the New England division to construct and inspect the pavements, and to prepare this and other subsequent semiannual reports covering the condition of the tar-rubber experimental test pavements, was given in a joint message form dated September 30, 1952, from Chief of Engineers, subject, Job No. New England Div.–52 ACRP–AF, Directive No. 2.

4. *Supplemental construction.*—The basic design and construction of the test panels, including 80 feet of taxiway M adjacent to the runway extension, is described in the basic report dated January 1953. Remaining portion of taxiway M, which has a 3-inch asphaltic concrete pavement, was completed during the 1953 construction season. This pavement is of the same construction as the asphaltic concrete test panels.

Blast pads, consisting of 2 inches of asphaltic concrete surface course mixture, were constructed in 1 course over 4 inches of select gravel base under a supplemental agreement to the original contract for construction of the runway extension and taxiway M. The blast pads are located at the south end of the north-south runway and taxiway M, adjacent to the test panels, as shown on plate No. 1. These pavements have no connection with this investigation, but they are mentioned for information of personnel having reason to inspect the pavements in the future.

5. *Traffic history.*—Table No. 1 lists the actual number of operations (landing and takeoffs) for each type of aircraft using the test pavements during the second 6-month period after construction, and also the total number of operations for each type of aircraft during the entire first year.

In this connection, and referring to table No. 1, it is noted that 37 different types of airplanes including bombers, fighters, and trainers operated on the various test pavements during the entire year, as compared to 28 types of aircraft which operated during the initial 6-month period. The total number of operations during the entire 12-month interval was 5,859 landings and 5,896 takeoffs, of which 4,018 landings and 4,027 takeoffs were recorded during the second 6-month period. This represents an increase in traffic of 218 percent for the second 6-month period as compared to the first 6-month period.

For the 12-month period, most of the traffic was by C–47, F–89, F–94, and T–33 types of aircraft, each type making more than 500 landings and takeoffs, with total number of operations by these aircraft accounting for about 79 percent of the traffic. However, by far the greatest volume of traffic (about 41 percent) was by F–89 type aircraft which made approximately 2,400 landings and takeoffs, of which only 13 took place during the first 6-month period.

6. *Condition survey*—(a) *General.*—Observations after 12 months' use indicate the general condition of the pavement test panels to be good, with no major changes having occurred since the initial 6-month inspection and no cracking of the pavement proper having taken place. Since the last inspection, a few additional short, transverse (longitudinal with respect to direction of paving) hair cracks were observed along some of the construction joints. One new longitudinal crack (transverse with respect to direction of paving), varying in width from nearly zero to one-eighth inch, was observed in lane 2 of Flintbinder panel A4 as shown on plate No. 1. This crack is apparently at a construction joint located between the two largest cracks previously reported as having developed on either side of the lane. A photograph of the new crack is shown on plate No. 2 and, with reference to plate No. 1, it is noted that the crack is at the center line of a small elliptical blast pattern, so that it is possible that it is related to, or at least was exposed as a result of, jet blast.

The 2 major cracks which are on either side of lane 2 of Flintbinder panel A4 which were developed during the first 6-month period, appear to be in the same condition as previously observed, with no apparent indication of further openings, as revealed by comparing the recent photograph included to the left of plate No. 3, with an earlier photograph of the same crack shown on plate No. 2 of addendum No. 1.

The largest crack which has developed since the first 6-month inspection was observed at the joint between lanes 2 and 3 of Flintbinder panel D–4. A photograph of this opening, which is about 10 feet long by one-eighth inch in maximum width, is shown on the right of plate No. 3.

Raveling of the construction joints which was previously reported in addendum No. 1 is still present, but does not appear to have worsened, as shown by comparison of the photograph of a typical raveled joint on plate No. 4, which was taken at the time of this inspection, with the photograph of the same joint shown on plate No. 2 of addendum No. 1 taken 6 months earlier. However, raveling of construction joints has occurred at other locations since the last inspection, as shown on plate No. 1, although the test panels were rolled subsequent to addendum No. 1 with several passes of a lightweight pneumatic-tired roller, during warm weather.

Locations of all pavement failures, including cracks and raveled areas which have occurred to date, are shown on plate No. 1.

The general locations, maximum widths, and approximate lengths of cracks developed during the second 6-month period, and the type of pavements in which they occur, are summarized below:

Panel	Location of crack (between lanes)	Type of pavement	Approximate length of crack (feet)	Maximum approximate width of crack (inches)
A1 and A2	3 of A1 and 1 of A2	Asphalt and Surfa-Aero-Sealz	6	1/16
A4	Across lane 2	Flintbinder	10	1/8
B2	2 and 3	Surfa-Aero-Sealz	5	1/8
B3	1 and 2	Tar	12	1/8
B3 and B4	3 of B3 and 1 of B4	Tar and Flintbinder	5	1/8
D4	2 and 3	Flintbinder	10	1/4
E1 and E2	3 of E1 and 1 of E2	Asphalt and Surfa-Aero-Sealz	20	1/16
E4	2 and 3	Flintbinder	15	1/16

The general locations, maximum dimensions, and types of pavement observed, where raveling has occurred during the second 6-month period, are as follows:

Panel	Location of crack (between lanes)	Type of pavement	Maximum dimensions		
			Length (feet)	Width (inches)	Depth (inches)
A1 and A2	3 of A1 and 1 of A2	Asphalt and Surfa-Aero-Sealz	65	1½	¼
A2	2 and 3	Surfa-Aero-Sealz	15	1½	½
A2 and A3	3 of A2 and 1 of A3	Surfa-Aero-Sealz and tar	6	1½	½
A3	1 and 2	Tar	23	1	¼
A3	2 and 3	Tar	50	1	¼
A3 and A4	3 of A3 and 1 of A4	Tar and Flintbinder	6	2	½
A4 and B1	3 of A4 and 1 of B1	Flintbinder and asphalt	80	1	¼
B1 and B2	3 of B1 and 1 of B2	Ashpalt and Surfa-Aero-Sealz	30	1	¼
B2 and B3	3 of B2 and 1 of B3	Surfa, Aero-Sealz and tar	50	1	⅛
B4	1 and 2	Flintbinder	15	1	⅛
C1 and C2	3 of C1 and 1 of C2	Asphalt and Surfa-Aero-Sealz	3	2	¼
C4	2 and 3	Flintbinder	30	1	½
D1 and D2	3 of D1 and 1 of D2	Asphalt and Surfa-Aero-Sealz	3	4	¼
D2	1 and 2	Surfa-Aero-Sealz	40	2	⅜
D3	1 and 2	Tar	10	2	½
D3	1 and 2	Tar	20	3	⅜
D3	2 and 3	Tar	10	2	½
E3	2 and 3	Tar	10	2	⅜

Based on the above and similar data reported in addendum No. 1, it appears that most of the cracking has occurred at joints where at least one of the lanes consists of the Flintbinder mixture. Also, although most of the raveling observed at the end of the first 6-month period was reported in addendum No. 1 as having taken place along joints constructed with Surfa-Aero-Sealz mixture, the last inspection shows raveling to have occurred at other joints where different materials were used in adjacent lanes. No raveling was observed within panels constructed entirely of asphaltic concrete.

(*b*) *Damage by jet blast.*—Damage by jet blast was observed to have occurred in 10 new locations, the areas of pavement erosion being of various sizes and elliptical shaped. Locations of the new damaged areas are shown on plate No. 1. Six of these areas are located in the asphaltic concrete test panels, with the ends of five of the areas extending into adjoining test panels consisting of Surfa-Aero-Sealz and Flintbinder tar-rubber mixtures. The remaining four areas lie within panels constructed of the tar-rubber and tar mixtures.

The largest eroded area extends over almost the full widths of test panels C1 and C2, which consist of asphaltic concrete and Surfa-Aero-Sealz, respectively. The center of this area, which is about 55 feet long by 12 feet wide, is located very close to the joint between the two panels so that the areas of erosion in both types of material are about equal. Photographs of this area are shown on plate No. 5, the photograph on the right of the plate showing a general view of the damaged area and the photograph on the left showing the condition of pavement at the joint between the two panels. The depth of erosion in the Surfa-Aero-Sealz panel is too small to be measurable, whereas, in the adjoining asphaltic concrete panel, the depth of erosion ranges from one-quarter to three-eighths inch. Similar conditions, with marked differences in depth of erosion in adjacent panels of Surfa-Aero-Sealz and asphaltic concrete mixtures, were observed at two other locations, one location being in test panel E2 at the joint between lanes 2 and 3, and the other location being in test panel E1 at the joint between lane 3 of panel E1 and lane 1 of panel E2. At both of these locations depth of erosion was too small to measures in the Surfa-Aero-Sealz panel and ranged from one-eighth to one-quarter inch in the asphaltic concrete panel.

Where blast areas covered joints adjacent panels consisting of Flintbinder and asphaltic concrete mixtures, there was no pronounced difference in depths of erosion in the two materials, the depths of erosion in both panels being negligible. A photograph indicating the maximum erosion in any Flintbinder panel, as a result of jet blast during normal operations, is shown on the left side of plate No. 6. One-half of the elliptical-shaped blasted area, measuring about 10 feet by 10 feet was well defined in lane 3 of test panel A4, although depth of erosion was not measurable. However, the other half of the blasted area on the adjacent lane was not defined, although the construction joint between the two lanes was opened, as shown on plate No. 3, and white paint had been lifted from the pavement, as shown on plate No. 6.

A large area in tar, panel C3, and extending into Flintbinder, panel C4, appeared to be generally "rough" with no definite blast pattern having been formed. Depth of erosion was not measurable, but some of coarse aggregate at the surface in the tar panel appeared somewhat bare and evidently had been stripped of its tar film. Approximate size of this area is 35 feet long by 15 feet wide. A photograph of the area is shown on plate No. 6. Other tar panels apparently had not been affected at the time of inspection.

In general, maximum depth of blast erosion occurred in the asphaltic concrete panels, the maximum depth of three-eighths inch being observed at three locations, namely, in panel C1 as discussed above, and at two locations in panel B1. One of the latter two areas was reported in addendum No. 1 as representing the maximum extent of damage due to jet blast resulting from normal operations at end of the first 6-month period, at which time the depth of erosion was not measurable. A recent photograph of this area which is about 30 feet long by 6 feet wide, about the same as reported in addendum No. 1, is shown on plate No. 7.

The approximate dimensions of the eroded areas and panels in which erosion has occurred to date as the result of normal jet aircraft operation are as follows:

Location of blast area (panel number)	Type of pavements	Extent of damage		
		Length (feet)	Width (feet)	Depth (inches) [2]
A4	Flintbinder	10	10	NM.
A4 and B1	Flintbinder and asphalt	30	10	NM and ¼.
Do.[1]	do	38	8	Do.
B1 [1]	Asphalt	32	10	⅛.
C1 and C2	Asphalt and Surfa-Aero-Sealz	55	12	⅜ and NM.
C3 and C4	Tar and Flintbinder	35	15	NM.
D1	Asphalt	22	6	NM.
D1 and D2	Asphalt and Surfa-Aero-Sealz	22	6	⅛ and NM.
D4 and E1	Flintbinder and asphalt	22	8	NM and ⅛.
E1	Asphalt	10	4	⅛.
E1 and E2	Asphalt and Surfa-Aero-Sealz	20	6	¼ and NM.
E2	Surfa-Aero-Sealz and asphalt	30	7	NM and ¼.

[1] Areas previously reported.
[2] NM = Not measurable.

Cracking and lifting of pavement paint was also observed on all types of pavement, the heat and force of the jet blasts apparently being sufficient to first crack and then lift small patches of paint from the pavement. However, there was no evidence that this cracking extended into the pavement proper. Photographs of typical damage of this nature are shown on plate No. 8.

(*c*) *Damage by jet-fuel spillage.*—Damage to pavement test panels as a result of jet-fuel spillage is again considered negligible. and, although spillage has occurred on all types of pavement mixtures as evidenced by the presence of stains, the only damage observed to date which can be attributed to this cause and which is unexplainable at this time is located in lane 1 of tar concrete panel F3. This area is 3 feet long by 6 inches in width and is the same area previously reported to have been damaged by spillage. The upper photograph of plate No. 9 shows the extent of damage at time of this inspection.

With reference to this photograph, it is noted that the outline of the original area covered by fuel is still apparent; however, the surface has hardened to form a resistant film except for two small localized areas which could be loosened easily to about an inch in depth. A closeup photograph of a typical jet-fuel spillage stain (regardless of type of pavement involved), located on asphaltic concrete taxiway test panel F1 immediately adjacent to the runway extension, is shown on plate No. 9. The area in which this stain occurs is used extensively for maneuvering jet aircraft into position for taking off. Except as noted above, no softening of pavement was apparent at any of the stain spots observed, regardless of the type pavement.

7. *Tests performed on pavement cores.*—In accordance with request of the Flexible Pavement Laboratory, Vicksburg, Miss., full-depth cores were obtained during September 1953 from the various test panels for test purposes in connection with another Flexible Pavement Laboratory study. Results of tests performed by the Flexible Pavement Laboratory are included herein to indicate properties of the various pavements at time of this inspection.

Three full-depth cores were obtained from various asphaltic concrete test panels, and six full-depth cores were obtained from various tar and tar-rubber panels. All cores were taken along the west side of the runway. At Surfa-Aero-Sealz panel A–2 and tar panel A–3, however, two attempts were required to obtain intact full-depth cores, the surface and binder courses becoming separated in the first attempts.

Results of tests on the separated core specimens, as compared with average as-constructed test properties, were forwarded to this office by letter dated December 9, 1953, from the office of the director, Waterways Experiment Station,

Vicksburg, Miss., to the division engineer, New England division, subject, Pavement Samples, Presque Isle Air Force Base. Results are summarized in the following table:

Type of pavement	Stability (pounds)		Flow (hundredths of an inch)		Unit weight (per cubic foot)	
	As constructed	11 months later	As constructed	11 months later	As constructed	11 months later
Tar (7.4 percent)	1,403	3,660	11	19	144.2	144.8
Surfa-Aero-Sealz (8.0 percent)	1,348	1,913	12	19	149.4	149.7
Surfa-Aero-Sealz (7.0 percent)	1,467	2,745	13	19	147.4	146.6
Flintbinder (7.7 percent)	1,700	2,478	13	20	148.4	146.3
Asphalt surface (6.2 percent)	634	644	9	20	143.4	141.9
Asphalt binder (5.0 percent)	461	686	12	19	155.0	144.5

In comparing the above results, the Flexible Pavement Laboratory reports, "that for all practical purposes and within the limits of sampling and testing error the unit weights of the pavements after 11 months are the same as when constructed." In this connection it should be mentioned that the average values as originally reported for the construction cores were based on a relatively large number of cores for each type of pavement, as compared to the limited number of cores tested at 11 months.

The Flexible Pavement Laboratory test results indicate that no significant change in stability occurred in the asphaltic concrete panels after 11 months of use but that substantial increases in stability for both the tar-rubber and tar panels took place. The flow values obtained by the Flexible Pavement Laboratory are from 7 to 11 points higher than the average values obtained during construction. In this connection, the Flexible Pavement Laboratory states that the increases in flow values are not serious and that there is no apparent reason for such to have occurred. Assuming that pavement densities in both cases are the same, as appears to be true for all practical purposes, the higher flow values would generally indicate the presence of a higher percentage of bitumen. However, the Flexible Pavement Laboratory, in letter dated July 16, 1953, to the division engineer, New England division, subject, Runway Extension Pavement, Presque Isle Air Force Base, Presque Isle, Maine, reported that results of extraction tests on similar in-place cores indicated a smaller amount of each of the bituminous materials to be present than the construction records indicate were actually used in the mixtures.

8. *Conclusions.*—Based on results of the pavement inspection at end of 12 months of usage by 37 different types of aircraft, as reported herein, the following conclusions are drawn relative to performance of the various test pavements:

(*a*) Although damage to any of the test pavements as a result of jet blast during normal operation is not extensive at this time, comparison of depths of surface erosion in the various test panels indicates that pavements constructed with tar or either of the tar-rubber materials are withstanding jet blast more effectively than are the asphaltic concrete pavements. In this respect, however, surface of coarse aggregate in the one tar concrete panel visibly affected appeared to have been stripped of its tar film, but blast pattern was not too well defined and depth of erosion was insignificant.

(*b*) Damage to the various types of pavement as a result of jet fuel spillage is negligible.

(*c*) A few additional small joint cracks, as a result of cold weather placement, has occurred; however, cracking of the pavement proper was observed at only one location, and this was evidently at a transverse construction joint.

(*d*) Some raveling of joints at additional locations has taken place, but extent of previously observed raveling has not increased to any noticeable degree.

DEPARTMENT OF THE ARMY,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., January 11, 1954.

Enger.
Subject: Investigation of tar-rubber pavements.
To: The Chief of Staff, United States Air Force, attention, Director of Installations, DCS/O–AFOAI–AE/Æ.

1. Reference is made to letter from Headquarters, USAF, to this office, subject, Design of Airfield Pavements, dated October 1, 1953, and subsequent two endorsements.

2. The results of the investigation of tar-rubber pavements to determine suitability for use on critical areas are as summarized below:

(*a*) Tar-rubber paving mixtures may be designed using criteria developed during the investigation that will resist shoving and rutting under the traffic of 100,000-pound wheel loads (dual wheels).

(*b*) Tar-rubber pavements are more resistant to spillage of jet fuel than asphaltic concrete pavements.

(*c*) Tar-rubber pavements are equal to asphaltic concrete in ability to resist blast of current-type jet aircraft based on limited tests conducted at Presque Isle Air Force Base, Maine.

NOTE.—An F–80 engine has just been received by the Flexible Pavement Laboratory, Vicksburg, Miss., and additional blast tests will be conducted on tar-rubber pavements.

(*d*) Tar and tar-rubber pavements harden with age, developing a surface which tends to be brittle. This hardening is accelerated by spillage of jet fuels.

(*e*) Traffic produced no distress in the leached asphaltic concrete binder course under the tar-rubber surface course in area of fuel spillage. Traffic may produce distress in a binder course severely leached by jet fuel under a tar-rubber surface course.

(*f*) Traffic caused rather severe cracking of the brittle surfaces of the tar and tar-rubber pavements in areas where jet fuel was spilled and caused some surface cracking in areas where no jet fuel was spilled.

(*g*) In view of the above, it is concluded that tar-rubber pavements will be a reasonable substitute for concrete pavements (for critical areas only) on airfields subject to the unknown effects of age and weather and subject to favorable price competition.

For the Chief of Engineers:

I. O. THORLEY, Jr.,
(For H. B. Zachrison, Chief Engineering Division, Military Construction).

[First endorsement]

DEPARTMENT OF THE AIR FORCE,
HEADQUARTERS, USAF,
Washington, D. C., January 27, 1954.

To: Office, Chief of Engineers, Department of the Army, Washington, D. C.
Subject: Investigation of tar-rubber pavements.

1. It appears to this headquarters that paragraphs 2 (*d*), 3 (*e*), and 2 (*f*) of basic letter are somewhat in conflict with conclusion set forth in subsequent paragraph 2 (*g*).

2. It is requested that your conclusions be rephrased to indicate definitely whether the results of tests to date justify the use of tar-rubber as a substitute for concrete for critical areas.

L. J. ERLER,
Colonel, USAF, Deputy Director of Installations, Deputy Chief of Staff, Operations.

[Second endorsement]

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., March 16, 1954.

To: The Chief of Staff, United States Air Force, attention: Director of Installations, DCS/O–AFOAI–AE/E.
Subject: Investigation of tar-rubber pavements.

1. It was not the intention of the basic letter to unqualifiedly endorse the use of tar-rubber pavements. Paragraphs 2 (*a*) through 2 (*f*) report the observed results of tests made on tar-rubber pavements as conducted by our Flexible Pavement Laboratory.

2. Without knowledge of the effects of age and weather, it appears that the tar-rubber pavements would perform better in critical areas than would asphaltic concrete. If initial costs of tar-rubber pavement prove to be substantially lower than for portland cement concrete, consideration of tar-rubber as a substitute for portland cement concrete might be warranted for use in critical areas, so long as cognizance is taken of its shortcomings as set forth in the basic letter. However, there are no known accelerated tests which would determine with reasonable certainty the durability of such pavements when subjected to weathering and aging.

3. We will continue our tests and observations on the effects of aging and weathering of tar-rubber pavements.

G. O. FINLEY,
Colonel, Corps of Engineers, Assistant for Planning, Engineering and Contracts, Military Construction,
(For the Chief of Engineers).

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